WINTER 1995

DIY boat owner

the MARINE MAINTENANCE MAGAZINE

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Refer to DIY 1998 #4 for updated Boat Wiring Handbook with more current standards and installation guidelines

Boat Wiring

Upgrading and troubleshooting marine electrical systems.

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TALKBACK

Q: I am enjoying your new magazine and congratulate you on it. My wife and I are considering taking our 1983 CS 27 into saltwater. We have heard conflicting views on what needs to be done to convert our inboard 8 hp Yanmar diesel engine for saltwater use and so turn to the experts. Your advice will be appreciated. What other things should be considered when converting a Great Lakes boat?
M. Jarvis, King City ON

A: Saltwater-proofing depends on the engine. As your engine is not equipped with a heat exchanger, a closed cooling system that uses freshwater, it will require regular maintenance. (Unfortunately, aftermarket heat exchangers are not available for your engine.) Sacrificial zinc anodes on the block must be checked and replaced periodically. How frequently, depends on engine hours and water temperature — zincs disappear faster in warmer water. Carry plenty of extras on board and record replacement intervals in your engine maintenance log. When leaving the boat for shoreside visits longer than one week, you must drain the saltwater out of the block and run freshwater through the system, similar to winterizing the engine with anti-freeze. Saltwater sitting in the engine accelerates corrosion. Corrosion is your biggest enemy in saltwater. It attacks poor quality wiring (see page 10), navigation lights and other electrical systems; and parts made of non-stainless steel. You'll need to grease all tools, metal zippers and the like. A good cleaner and some elbow grease removes most saltwater stains. Most production boats survive quite well in a salty environment, requiring only minor modifications.

Q: Your list for storing boats and motors in the Fall issue (*Winter Lay-up*) was great, but how do you keep mice out? Also, once gelcoat has oxidized, how do you restore its shine?
Bill Stanley, Kingsville, Ont.

A: I don't know if it's the toxic smell of polyester resins or fuel residue that attracts rodents to boats, but for many boat owners they are unwelcome tenants. Below floorboards, inside gunwales and motor wells, underneath cockpit seats, forepeaks and lockers are prime nesting sites for mice. Your first line of defence is to remove all potential nesting materials, such as cushions, paper products, rags and the like. Seal large vents and engine cowls to prevent entry into the cabin. Sprinkle mothballs in the bilge and lockers and other favored areas or try some household treatments. As for reviving oxidized gelcoat, this fall we tested various fiberglass gelcoat restorers on a sun-bleached hull and left it to sit for the winter. A complete report appears in our SPRING '96 issue.

TECHNICAL HELPLINE

Need help with a problem? Unable to find information on products or do-it-yourself projects?

DIY TALKBACK is a special reader service that makes available to you the resources of marine industry experts on topics such as boat repair, engines, trailers, electricity, plumbing, electronics, sails, maintenance and more.

Cost is FREE to DIY subscribers.

Send your questions to:
TALKBACK *via mail, or E-mail. Include your name, subscriber ID number (if known), boat name and home port in all correspondence.*

MAIL:
P.O. Box 22473
Alexandria, VA 22304

E-MAIL: info@diy-boat.com

TECH TIPS

BATTERY TLC: To preserve rechargeable batteries when not in use this winter, totally discharge to a "dead" state then fully recharge. Never leave the battery attached to the charger when full.

LINE GAUGE: Boaters usually carry an assortment of lines in different lengths and diameters heaped in various bundles in lockers. To quickly identify lines as mooring, anchor, tow etc., develop a system of colors to indicate length and mark the corresponding colors on the rope ends.

DRILL MATE: When positioning hardware on a mast or other vertical surface, temporarily hold fitting in place with self-sticking, adhesive-back pads (available at most hardware stores). To use, attach pads to hardware, drill one hole, insert fastener, then drill remaining holes. Remove pads, clean off any adhesive residue, bed fitting and fasten securely.

WATERPROOF STORAGE: Store clothes in various sizes of Ziploc bags. These not only keep everything dry and organized, you can easily see contents of the bag before opening.

DRYING AGENT: Lack of ventilation in boats kept under cover all winter accelerates mildew growth in cabins. This is easily remedied by opening all lockers and drawers and placing silica gel in cloth bags inside each compartment.

BOTTOM PAINT REMOVAL: Scraping bottom paint is a laborious task that's made easier with the help of a blade scraper. It works best with a slightly dull blade so take the supplied blade and file to a more obtuse angle. File as needed to maintain a good edge and keep a supply of spares.
From Ron Lehman, Brampton, Ont.

MORE LIGHT FOR LESS: On boats with limited battery capacity, use halogen bulbs to get the same light output with less current draw. These bulbs run hot, so provide adequate ventilation all around the fixture.

SPOT REMOVER: To remove paint specks or nail polish from wood, dip a cotton swab into nail polish remover, squeeze out the excess and lightly touch the spot. The remover will begin to dissolve the paint or polish. Repeat until all is removed. Don't rub too hard or you'll take off good varnish.

SUPER-DUTY CHAFE STRIP: Possibly the best chafing material is aircraft repair tape. A razor-thin strip of aluminum with an adhesive backing, it's impervious to solvents, cleaners, salt, grease and sunlight. A 5.0cm (2") wide strip placed under rope leads, blocks — just about anywhere chafing occurs — has protected the deck for 10 years and is barely worn.
From Vicki de Kleer, Mollyhawk, Oakville, Ont.

IF THE SCREW FITS: Use your drill index box to match the drill bit to the screw size. Insert the screw into the hole in the index box that just fits loosely and then use one size smaller. For example, a #12 wood screw fits loosely into a 7/32 bit hole; therefore use a 13/64 drill bit. Use a size smaller again if working with soft woods.

INVENTORY CONTROL: When storing bottles of cleaners and other chemicals in the bilge or a deep locker, label the top rim with a waterproof marker. This saves lifting out each bottle to inspect its contents.

RECYCLE FOIL: After you used aluminum foil to wrap food in for cooking on the barbecue, don't toss it away. Clean the foil, crumple into a tight ball and use as a steel wool substitute for cleaning pots and pans.

Tech Tips welcomes contributions from readers. If you have a boat-tested tip you'd like to share, send complete information along with your name, boat name and home port to: **DIY Tech Tips, P.O. Box 22473, Alexandria, VA, 22304 or E-mail to info@diy-boat.com.**

DIY boat owner

Boat Wiring

A complete guide to upgrading, expanding or modifying your boat's DC electrical system.

Many production boats come with sorely inadequate electrical wiring systems. Designed merely for the equipment installed at time of purchase, they come from the manufacturer with only the bare necessities: one battery, a single six-circuit fuse panel, and no means of monitoring the status of the electrical system. Moreover, a large number of boats are wired incorrectly or with non-marine-grade components that are highly susceptible to moisture, corrosion and certain failure; some older boats may even have solid core wiring commonly used in household AC circuits. Other elements in a marine environment — saltwater, oil, gasoline, diesel fuel, heat, cold and never-ending vibration — quickly consume a poorly installed wiring system.

Surveying and Planning

The type of refit discussed in this article is suitable for any pleasure boat up to 60m (200'). Your system may be as simple as a single battery and instrument panel or as complex as multiple batteries and circuits. Larger power boats will have more circuits but the principles remain the same.

Before upgrading or modifying your electrical system, you need to survey the existing components to determine what is salvageable and needs upgrading. Do a random check of wire conductors for discoloration and corrosion by stripping back the insulation at a few terminals. As long as wire and insulation are intact and pliable, and along with the terminals show no signs of corrosion, there is no need to replace.

With the survey completed, you need to compile a list of all your electrical needs. Include all electronic equipment you have on board plus any items you plan to add in the future; it's important to plan for expansion. If your boat's existing distribution panel is full, adding another six-circuit panel allows a separate circuit for each electronic device. More importantly, if there was ever a short on one circuit, it would not put any other devices out of use. To monitor the system, you'll need a voltmeter and ammeter. A voltmeter checks condition of the batteries and monitors the charge from the alternator or battery charger.

BLUE SEA SYSTEMS

Figure 1: A four-position master switch lets you isolate the batteries, select which battery requires charging or completely cut off all power.


BLUE SEA SYSTEMS

Figure 2: Bus bars centralize multiple wires, shortening multiple cable runs to common positive or negative power points.

The ammeter measures current loads in circuits and monitors alternator output. To be functional for marine use, the voltmeter should have an expanded scale (8 to 16 volts); the ammeter is sized to fit the boat's amperage range.

To meet additional power loads, consider adding a second battery and a three-way master switch (**Figure 1**). Mounted on a bulkhead close to the battery, this switch lets you isolate the batteries, reserving one (a starting battery) for the engine and the other (a deep cycle) for all other loads. You can also select which battery requires charging or completely disconnect all power. Multiple battery systems should also have a battery isolator coupled to a "smart" regulator. Both devices recharge batteries simultaneously without danger of one discharging into the other. In a dedicated battery system, where one battery is used solely for engine starts, you may elect to eliminate the master switch. In this case, the starting battery is connected to a 200-amp, single-pole key switch that lets you disconnect all power if there is an electrical short or emergency. This prevents accidental battery drain of the boat's main power source. The auxiliary battery connects to a similar switch. A master switch would be required only if the boat was equipped with two deep-cycle batteries, usually linked in parallel, so that the "Both" position on the switch charges them simultaneously.

TABLE 1:
DISTRIBUTION PANEL (FUSE)

	Circuit	Amps
Cabin lights**	1	0.6 x 4
Cabin fan		1.2
AM/FM cassette	2	1.0
Navigation lights	3	Port 0.8
		Stbd 0.8
		Steaming 0.8
		Masthead Trilight 2.0
		Deck light*1.6
Bilge pump	4	4.0
Compass light	5	0.1
Instrument lights		0.1
Cockpit light		1.7
Chart light		0.4
Spotlight	6	10
Autopilot	7	4.0
Depthsounder	8	0.1
VHF radio	9	4.5 max
Speedo/Log	10	1.5
Spare	11	
Spare	12	

*Halogen light
**Flourescent lights
(Note: To estimate amperage draw of any electrical device, divide its rated watts by the ship's voltage, either 12, 24 or 32 volts.)

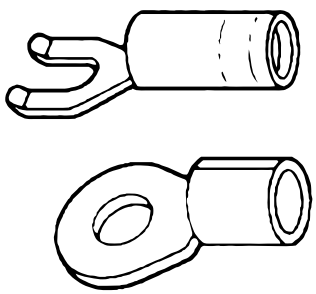


Figure 3: Ring or captive-spade type terminals are preferred since they will stay in place even if the attachment screw or nut works loose.

Now draw up a wiring plan. The easiest way to do this is to sketch the interior of the boat to scale, showing all electrical equipment and proposed routing of all wires. Where possible, follow existing wiring paths for there are only a limited number of ways to get from the bow to stern and side to side. Measure the approximate length of each wire from the battery, switchboard, or distribution panel to the electrical device and back. Allow an extra .9m (3') for slack at the ends.

TIPS

Never mix voltages inside the same panel. If 12 and 24 volt and shorepower panels are located in close proximity, design them so each is easily serviced without opening the other. Having to disconnect all power sources means you cannot use alternate lighting to see what you are working on.

Calculating Wire Size

Total load in amps on a circuit and wire size should be determined at this point. Both 12- and 24-volt systems are extremely sensitive to voltage drop. Even short lengths of wire can produce a voltage drop at high current draw. This is often evident when the lights dim as a fan, bilge pump or pressure pump starts.

Start by calculating the amperage of each device. If only wattage is known, divide it by the system's voltage, either 12, 24 or 32 volts. A fluorescent 6-watt light bulb, for example, draws 0.5 amps at 12 volts. Now determine which devices you can safely group on a circuit without overloading; 10 amps per circuit gives plenty of room for future expansion. Group items that are used together, such as cabin lights or instrument lights on one circuit, but attach no more than four terminals to any terminal stud. Items that are critical to a boat's safety (bilge pump, navigation lights, instruments) should be connected to separate cir-

Boat Wiring

cuits (see **Table 1**). Wire heavy current draw items, such as an electric anchor windlass, directly to the main distribution point or the battery, with a separate in-line circuit breaker. If necessary, split a circuit and run extra wires to keep the individual currents down. Overloaded wires will heat up, a potential source of fire.

To minimize the number of circuits for low current loads, consider mounting sub panels. Instead of having a circuit breaker for each navigation instrument, have one 20 amp breaker marked navigation and use a sub panel of four or six switches without fuses right at the chart table to control separate items like night light, main light, log and navigation receiver. Many of these devices come with their own fast-blow, in-line fuse on the power wire lead. You should retain these fast-blow fuses to protect the instrument. The galley area is another instance where a single large amperage breaker with multiple switches placed close at hand makes good sense.

Before determining wire sizes, you need to estimate voltage drop. This value is proportional to wire size and length of the circuit between the power source (a battery, distribution panel or instrument panel) to the electrical device and back to the negative source. Lengthy distances require larger wire to prevent excessive drop. For electrical devices where voltage must be keep to a minimum to ensure the safety of the boat or passengers, such as navigation lights, navigation receivers (GPS, loran or radar) or bilge blower, wire is sized for a maximum voltage drop of 3% (see **Table 3**). Wire sizing for other non-voltage-drop sensitive equipment, such as interior or instrument lights, is based on a voltage drop of 10% or less (see **Table 4**).

Knowing the amperage requirements and voltage drop on any given circuit, you can now compute wire size and length. Remember: the number of wires installed on any one circuit is limited to the size and total length of the wire and the amperage of the fuse or circuit

TIPS

DC wires installed within .9m (3') of a compass or sensitive electronics, should have the positive and negative wires twisted in a continuous spiral in pairs to reduce magnetism induced by a flowing current. Ancor Marine offers a twisted pair cable with a braided shield for sensitive installations.

TABLE 3:

RECOMMENDED WIRE GAUGE SIZES (AWG)
12-VOLT SYSTEMS FOR 3% VOLTAGE DROP

Total Current in Amps	*Length 3/10	4.5/15	6/20	9/30	12/40	15/50
5	18	16	14	12	12	10
10	14	12	12	10	8	8
15	12	10	10	8	6	6
20	12	10	8	6	6	4
25	10	8	8	6	4	4
30	10	8	6	4	4	2
40	8	6	6	4	2	2
50	8	6	4	2	2	1

*Length of wire from the positive power source (battery, panelboard or switchboard) to electrical device and back to the negative power source in metric/feet.

Source: 1990 ABYC

TABLE 4:

RECOMMENDED WIRE GAUGE SIZES (AWG)
12-VOLT SYSTEMS FOR 10% VOLTAGE DROP

Total Current in Amps	*Length 3/10	4.5/15	6/20	9/30	12/40	15/50
5	18	18	18	18	16	16
10	18	18	16	16	14	12
15	18	16	16	14	12	10
20	16	16	14	12	10	10
25	16	14	12	10	10	8
30	14	14	12	10	8	8
40	14	12	10	8	8	6
50	12	12	10	8	6	6

Note: This table is used for devices not involving the safety of the vessel or its passengers.

*Length of wire from the positive power source (battery, panelboard or switchboard) to electrical device and back to the negative power source in metric/feet.

Source: 1990 ABYC

breaker (refer to **Tables 3** and **4**). For example: a circuit carrying 20 amps a distance of 4.5m (15') requires a #10 wire to keep the voltage drop to 3%; a #16 wire for a 10% drop. Positive and negative wires must be sized the same, since each carries an equal load. Generally, #12 or #14 AWG will be adequate for most applications; it is always better to err on the side of caution and use the larger size. Tally all lengths and add the sum to your shopping list.

Materials

When purchasing electrical components, it's imperative you use only marine-classified products manufactured to UL/CSA, SAE as well as coast guard and American Boat & Yacht Council (ABYC) standards. Automotive terminals, wire and switches do not belong on any boat. Some automotive parts stores sell products that meet marine standards, so it's important that you know what you're buying.

Wire must be fine-stranded, which means it has plenty of strands; a minimum of 19 is standard. Fine multiple strands are more flexible and are necessary for vibration-prone areas. Look for tinned copper wire (**Figure 4**) that has up to three times more corrosion resistance than copper, which often corrodes under the plastic covering; tinning prevents this corrosion. Wire is sold in different diameters and colors; the larger the American Wire Gauge (AWG) number, the smaller the wire. Never substitute AWG wire with SAE, an inferior wire designed for surface vehicles such as cars, motorcycles,

TIPS

Use yellow wire for negative grounds rather than black which may be confused with the AC hot wire which is also black.

Figure 4: Never use SAE wire (left), an automotive copper wire that has few strands and is 12% smaller that marine grade. Multiple-stranded, tin-plated copper AWG wire (center) is more flexible and offers three times more corrosion resistance than SAE. To reduce magnetism when routing wires near compass or sensitive electronics, use a twisted pair cable (right) with a braided shield (Ancor Marine).

CRIMPING TECHNIQUES

1 Select the terminal that is correctly sized to the wire.

2 Using the proper stripping die on the crimping tool or an automatic wire stripper (Ancor Marine), strip about 6.3mm (1/4") to 7.9mm (5/16") of insulation off the wire (**Picture 1**).

3 To ensure a positive connection, make certain all terminals and wire strands are free from oxidation and corrosion.

4 Place the connector in the crimp tool and insert the stripped wire. The wire insulation should be flush against the barrel of the connector. Make sure the strands do not extend into the contact area.

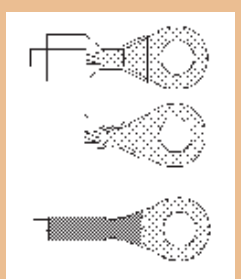
5 Center the crimp in the die and firmly squeeze the handles. If using double crimp terminals, crimp the insulation sleeve (**Picture 2**). For butt connectors, crimp each end. A single crimp is all that's needed. If cracks appear in the connector barrel or insulation you're using the wrong die.

6 Lightly pull the finished crimp to see that the wire is held firmly in place.

7 Waterproof the connection with heat-shrink tubing (**Picture 3**).

8 Support wire at (8") intervals and at both terminal ends with screw-type cable clamps or ties. Identify wire with numbered, stick-on labels (**Picture 4**).

J. MUNDY



INSTALLING ADHESIVE-LINED, HEAT-SHRINK TERMINALS: (1) Strip wire and insert into crimp barrel; (2) Apply crimp with proper die on crimp tool; (3) Heat connector until insulation fully recovers and adhesive flows freely.

etc., that is up to 12% smaller than AWG. It's a good practice to follow the recommended color code for general purpose and accessory wiring on boats (see **Table 5**). You may use other colors provided they are clearly marked on the wiring diagram. The only exceptions: red leads on positive circuits and black or yellow on negative. Try not to mix colors from one end of a circuit to another. It makes tracing and troubleshooting later on extremely difficult. Color-coded wires inside a common jacket simplify wiring and are readily available from most marine or electronic supply stores.

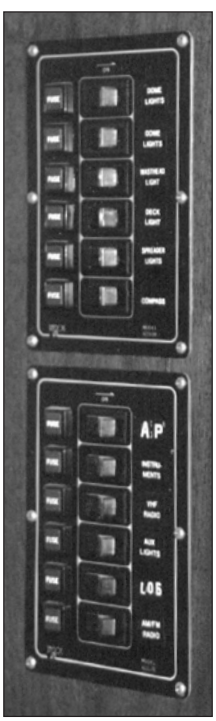
BLUE SEA SYSTEMS

Figure 5: A negative consolidation terminal such as the PowerPost+, provides an attachment point for multiple negative cables, allowing a single cable to connect to the engine ground.

All wires are terminated with crimp or swage-type **terminals** made of tinned copper or brass and seamless. Ring or captive-spade types (**Figure 3**) are preferred since they will stay in place even if the screw works loose, which causes the circuit to first become intermittent without the wire dropping off and may cause a short elsewhere. Terminals must be sized correctly to the wire being used: yellow for 10 to 12 gauge; blue for 14 to 16 gauge; and red for 18 to 22 gauge. While common practice for many years has been to solder the wire ends, properly applied crimp terminals are accepted by the coast guard, ABYC and others. As most solder joints are "cold joints," galvanic corrosion may cause premature failure.

Soldering also creates hard spots and prevents multi-strand wire from flexing. Eventually, vibration causes wires to break at the solder joint. If you insist on soldering, you must also use a crimp-on terminal. Never use household-type, twist-on connectors (also called wire nuts or Marette plugs) that cannot withstand the vibration and pounding.

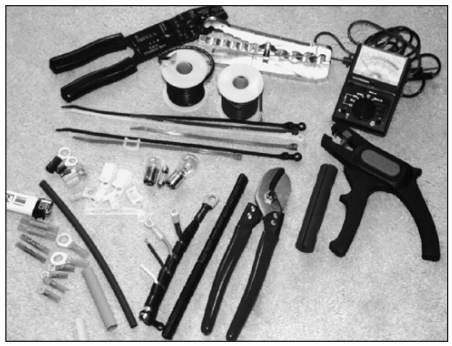
Distribution panels or panelboards (**Figure 7**) have either fuses or circuit breakers. Fused panels are less expensive than panels with circuit breakers but you'll need to carry spare corrosion-resistant fuses. Circuit breakers do offer several advantages over fuses. Sealed magnetic breakers are temperature independent and provide the same degree of protection regardless of ambient temperature. Breakers have a delay curve built in to compensate for momentary start-up surges above the nominal rating. Unlike fuses, the protection mechanism is corrosion proof. A corroded fuse holder can build up resistance causing overheating and a blown fuse; breakers are resettable, allowing power to be restored quickly once the fault has been cleared.



J. MUNDY

Figure 7: A separate circuit for each electrical grouping (cabin lights, for example) or electronic device is easily identified on the panel.

Figure 6: A typical DC electrical tool kit for DIY installations: crimp tool, lug crimper, multimeter, wire stripper, coaxial cable stripper, AWG wire, cable ties and clamps, fuses, assorted crimp and heat-strink terminals, butane lighter or heat gun, heat-shrink tubing, spiral wrap, wire/cable cutter and wire markers (missing).



The Right Tools

Your DIY electrical kit should include (**Figure 6**): wire cutter, wire stripper and crimp tool, assortment of screwdrivers, needle nose pliers, assorted ring terminals and butt connectors, heat-shrink tubing, #14 AWG and #12 AWG wire, wire markers, nylon cable ties and clamps, spiral wrap, spare fuses, multimeter and test lamp (optional).

A general all-purpose crimping tool ($10) sold by automotive suppliers is usually inadequate for marine use. A good quality crimping tool locates the terminal so that the seam is in the right position and all crimps will be secure. The better ones are designed so the jaws are properly matched for the particular terminal and won't release until the crimp is properly formed. Look for one that has dies for both insulated and non-insulated connectors in three sizes: #8 to #10; #12 to #14; and #16 to #18. You may pay as much as CDN$60/ US$40 for a heavy duty crimp tool: the payback is peace of mind and a safe, trouble-free installation.

Putting it all Together

The heart of a boat's DC electrical system is its power source: the battery. From here, a positive cable (preferably #8 AWG or larger) leads to a master switch, distribution panel or switchboard (instrument panel).

Boat Wiring

The negative battery cable goes to a ground, most often to the engine negative terminal. Any electrical device or appliance in contact with bilge water or seawater (windlass, bilge pump, washdown or shower pump), must also have the non-current-carrying cable (cold) connected to a ground to minimize stray current corrosion. Rather than attach multiple negative cables directly to the engine, a better method is to attach wires to a DC grounding terminal post, such as the PowerPost+ made by Blue Sea Systems. A single cable then connects directly to the engine ground.

Securely mount the second battery, then install the master battery switch in a dry location that's easily accessed — you may need to quickly shut off power in case of an electrical fire. Using a cardboard template of the distribution panel, select a location that is easily accessible, well-ventilated and protected from rain and spray. Allow a minimum of 10cm (4") behind the back of the panel; the exact amount is determined by meter size and type of fuse holder or circuit breaker installed. You would be surprised at how much space bunched wires take up.

Check your wiring plan and bundle wires passing along the same route. To facilitate passing wires from one location to another, group all wires together first, then pull the whole bundle as one harness. Run wires neatly in straight lines, following the perimeter of bulkheads, deckheads and cabin interiors; do not run across on a diagonal. When you pass a wire or cable bundle through a bulkhead, protect insulation from chafe by inserting a rubber bushing or smooth-edged plastic grommet. For greater protection, bundle wires with plastic spiral wrap, which is sold in diameters from 3mm (1/8") to 2.54cm (1"). Routing wires through an area that's difficult to access, such as under the floor or deckhead, generally requires hand feeding, pushing the wire through one way or the other. If you can follow an existing wiring harness, use one wire as a "messenger." Disconnect an independent wire or cable from the panelboard or instrument panel, tape the new wire and a return line (#4 polyester cord works best) to the wire, then pull it through until it exits. Remove the new wire and using the messenger, pull the old wire back to the starting point. It's important to label or tag each individual circuit (wire) before pulling them through or you will have a tough job tracing each circuit afterwards.

Never run bundles of wires through the bilge where they might get submerged in water. All connections and splices should be made

TABLE 5:
RECOMMENDED WIRE COLOR CODES FOR MARINE INSTALLATIONS

Color	Item	Use
Black/yellow	DC ground	Return, negative mains
Black/yellow	Ignition stop	
Lt. blue	Oil pressure	Oil pressure sender to gauge
Dk. blue	Cabin and instrument	Fuse or switch to lights
Blue/stripe	Tilt up and/or trim out	Tilt and/or trim circuits
Brown	Generator armature	Generator armature to regulator
	Alternator charge light	Generator terminal or alternator auxiliary
		Terminal to regulator
	Pumps	Fuse or switch to pumps
Brown/white	Trim position sender	
Green	DC grounding	Grounding wires (if insulated)
Green/yellow	DC grounding	Grounding wires
Green/stripe	Tilt down and/or trim in	Tilt and/or trim circuits
Grey	Navigation lights	Fuse or switch to lights
	Tachometer	Tachometer sender to gauge
Orange	Accessory feed	Ammeter to alternator or generator output and accessory fuses or switches
	Common feed	Distribution panel to accessory switch
Pink	Fuel gauge	Fuel gauge sender to gauge
Purple	Ignition	Ignition switch to coil and electrical instrument
	Instrument feed	Distribution panel electrical instruments
Red	Main power feeds	Positive mains (particularly unfused)
Yellow/Brown	Generator field	Generator to regular field terminal
	Bilge blowers	Fuse or switch to blower
Yellow/Red	Starting circuit	Starting switch to solenoid

Source: 1990 ABYC Standard E-9

high above normal water levels. Don't bury in-line splices away in some hidden corner. Wire splices must be protected against water or moist salt air, especially in bilge areas or on deck. If you have to make a splice, use a crimp-on butt connector and heat-shrink tubing (see page 14) to insulate and seal. Keep detailed notes of what wires you ran where and which circuit feeds what equipment.

Strip wire with the properly sized stripping edge on the crimping tool or use an automatic wire stripper, a handy tool that cuts and strips wire to the exact length in one squeeze of the trigger (available from Ancor Marine). Never use a knife that can easily nick the conductor and cause the wire to fail under vibration, loosening the entire joint. One of the most common electrical problems and potential sources of fire is a terminal that is loose on the terminal stud or wire. This creates a high-resistance path and overheats. Always use the correct size terminal and proper crimp tool. Follow wire preparation and crimping procedures on page 14. Problems with crimped connections are usually caused by using wrong tools, technique or

TIPS SOURCES OF WIRING FAILURES

Loose crimp on wire terminals.
Loose screws on panels, switchboards or terminal bus.
Unsecured wires or terminals.
Bad ground.
Corroded wires or connectors.
Worn insulation on wire causes a short circuit.

WIRING SENSITIVE NAVIGATION EQUIPMENT

By Arild Jensen

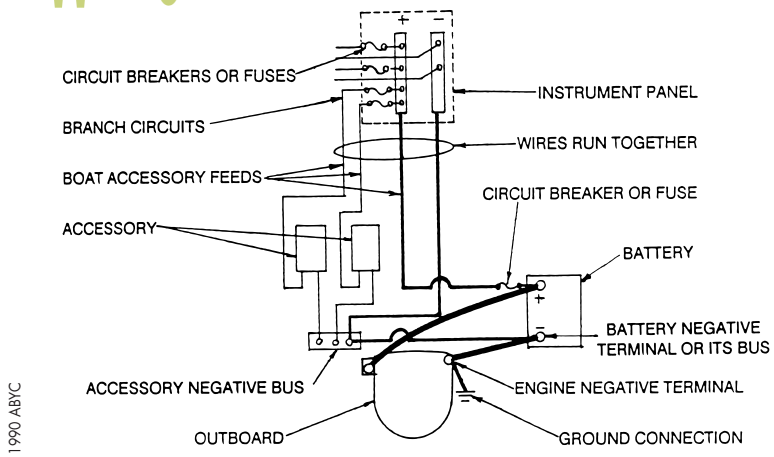
Navigation instruments are sensitive to electrical noise created by motors, relays and other appliances. Momentary voltage drops created during heavy current surges can play havoc with computerized GPS or loran receivers. Motors and alternators can produce electrical noise in the power lines that disrupt reception thus rendering your navigation and communication receivers useless.

Sailboat auxiliaries are especially prone to this problem. When under sail everything works fine. Start the engine, however, and the voltage dips, momentarily causing the navigation receiver to go haywire. Loran sets often have to be shut down and reset with a new initialization point. GPS receivers may recover on their own but only after several minutes wait.

Navigation equipment should be provided with a separate circuit fed from the battery with large size wires to isolate heavy current draw circuits from noise-sensitive circuits. The cable joining the distribution point to the battery should be very large, #4 AWG or larger if your maximum total draw is more than 20 to 30 amps.

Several products on the market help overcome these difficulties. Newmar makes two versions of a backup power supply filter. The basic device is a gel cell battery with a diode and isolating relay. The coil wires are run out to the starter's solenoid connection. When you turn the key to start the engine, the relay disconnects the receiver from the ship's battery. The internal battery provides enough power to keep the receiver going during the voltage dip. The diode provides a charging path so the gel cell recharges from the engine alternator when the engine is running. A more sophisticated version has additional filtering circuits that are more suited to a powerboat containing multiple sources of noise such as automatic water pumps, fans, refrigerator motors and air conditioning. Provision is made for two start circuits in dual engine boats. In either unit, the gel cell has enough power to keep the navigation receiver running long after the main battery runs out. In an emergency, this may be enough to obtain an exact fix when radioing for help.

Boat Wiring



Typical Outboard DC System

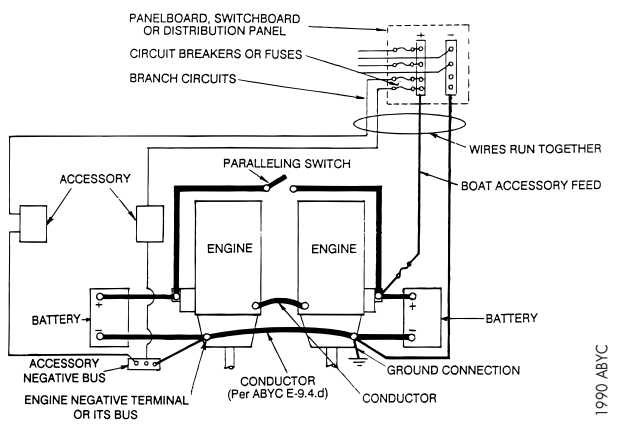
When wire runs have to be joined, split, or have a removable connection point use a terminal bus (**Figure 2**). This device is also used to shorten multiple cable runs to common positive or negative power points. Mount bus blocks in a dry location as high as possible. Never mount a terminal strip directly on any metal surface that is electrically connected to a metal hull. Trapped moisture will provide a leakage path for electrical current, resulting in stray current corrosion and extensive damage. Metal boats must provide an insulated surface (wood or other) as screws could short out to the conductive surface underneath. If you must mount a bus on a metallic surface, either get the type with a blind hole covered by insulation or use insulated liners available from the manufacturer. Shield all positive connectors and any terminal bus with an insulating cover to prevent shorting. Terminal strips and all positive connectors should have a protective box or insulating cover to prevent accidental shorting.

Label the wire at both ends near each terminal. Electrical suppliers stock a variety of wire ties, numbered tags and stick-on labels. Alternatively, you can write on white or light colored heat-shrink tubing with a ball point pen. This provides a permanent wire marking. Connect terminals to the terminal block or panelboard leaving some slack in the wires to prevent them from pulling loose under vibration and give room for repairs. Protect wires from abrasion in lockers with a conduit made of PVC pipe, available at hardware stores. Drill small holes in the pipe at low spots for water drainage. Wires and cables not run in a conduit must be carefully supported throughout at 46cm (18") intervals or less with snug-fitting screw-eye cable clamps or ties screwed to a secure surface. Wires should also be fastened near each terminal and at either side of a butt splice. If you do not want to drill screw holes, use adhesive-backed mounting pads. Never use these in engine rooms or other high-temperature areas as heat softens the glue and pads falls off. Use cable ties to fasten additional wires to existing wiring that is already routed and firmly secured. Finally, spray the entire surface with a heavy duty corrosion inhibitor.

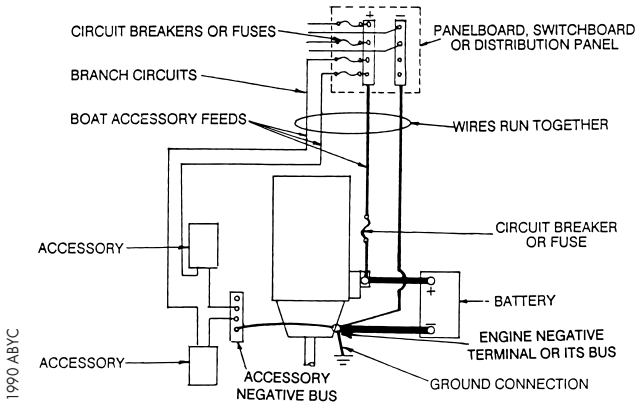
Improper wiring is the most

materials. Many crimp terminals fail when the wire breaks off just past the crimp where the wire flexes the most. Blinking lights are an early warning to inspect and tighten all loose screws on panels and terminal blocks.

Use marine-grade heat-shrink tubing (such as those made by Ancor Marine) to waterproof connections and protect against accidental shorting.(Do not use silicone sealant to waterproof connections for it releases acetic acid as it cures and may cause premature failure.) The tubing slides over the wire, or the terminal if already crimped. Heat is then applied to the tubing with a butane lighter or heat gun (the kind used for paint stripping) to make an airtight seal. Some shrink tubing has an adhesive lining that when heated, seals the tubing to the wire insulation. For areas where connections are exposed to immersion (bilge pumps) or subject to rain, spray or splash, Ancor Marine produces a three-in-one terminal with a connector, terminal and heat-shrink tubing in one unit that is CSA and UL approved for prolonged submersion.



Typical Twin Engine Inboard DC System



Typical Single Engine Inboard DC System

common source of fire in boats. Anyone contemplating a major overhaul of their boat's wiring system should first consult ABYC's Standards and Recommended Practices for Small Craft, sections E-8 and E-9; also in Canada, the Canadian Standard Association standards covering DC wiring for boats; and in the US, National Fire Protection Association's National Electric Code. If in doubt, consult a marine electronics technician.

Editor's Note: This article was based on a story submitted by Arild Jensen, who retrofitted a Sirius 21.

INFORMATION SOURCES

Books

Boatowner's Mechanical and Electrical Manual, Nigel Calder, 520 pgs.

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The 12 volt Doctor's Practical Handbook, Edgar J. Beyn, 233 pgs. *The 12 Volt Doctor's Project Book*, Edgar J. Beyn, 57 pgs.

The 12-volt Bible for Boats, Miner Brotherton, 174 pgs.

Boat Electrics/Helmsman Guides, James Yates, 128 pgs.

Wiring 12 Volts for Ample Power, D. & R. Ishihara Smead, 224 pgs.

Videos

12 Volts Made Easy, 60 min., Bennett Marine Video

The 12 Volt Sailor, 60 min., Bennett Marine Video

CAST OFF

Simple Docking System for Shorthanded Crews

Approaching a dock is probably one of the most challenging maneuvers a skipper can perform, especially in strong wind and current. This task is simplified with a large crew. The helmsperson approaches alongside the dock, crew members jump ashore with bow and stern lines in tow and secure the boat. Conditions change, however, when boating shorthanded or single-handed. The first mate jumps on the dock, holding both dock lines, balancing between the two until the skipper can come ashore and grab one of the lines. Single-handlers often lose complete control as the wind or current pulls the stern (or bow) away from the dock.

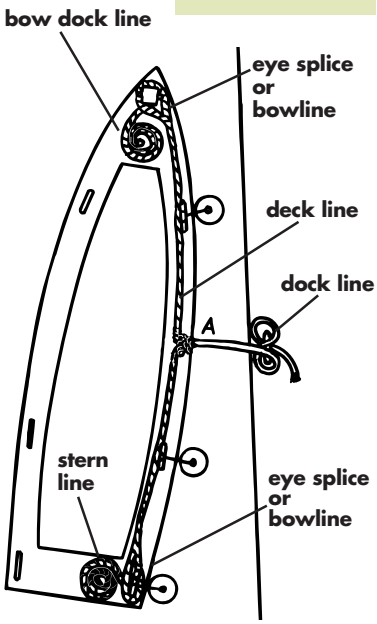
A fast and controlled way to dock is with this simple docking system we call the "dock-mate." It provides better control than a single line to a midship cleat (a piece of hardware many boats are without) for you never loose contact with the boat: yank in the "deck" line, and working along the line to the ends, pick up the bow and stern lines.

The dock-mate requires two lines. One, the deck line, is the length of your boat plus an extra 3m (10') or so for slack. To the center of this line is tied a 7.5m (25') dock line. Both are the diameter of the boat's regular dock lines. The deck line fits between the bow and stern cleats and leads outboard of all stanchions and shrouds (sailboats) with plenty of slack. Make a large eye in each end of the deck line and either secure with a splice or tie a bowline **(Figure 1)**. Eyes should be large enough to easily drop over bow and stern cleats. The smaller dock line, about 7.5m (25') in length, attaches amidships at maximum beam, close to the boat's pivot point (marked "A" on the drawing). Fasten with a knot that won't slide along the line. A double becket bend works best (see below).

To use the dock-mate, loop the ends over the mooring cleats on the appropriate side. Have the bow, stern and spring lines ready to pick up from dockside. Come alongside the dock, making your approach so a cleat on the dock is positioned amidships. Have plenty of fenders to protect the topsides. Slowly approach the dock, maneuver into position, step ashore holding the dock line and secure to an adjacent cleat. With the boat secured amidships, it will lie securely, parallel to the dock. Now work your way along the deck line, picking up the bow and stern lines and tie off. Which line you secure first depends on wind and current conditions.

This boat-tested tip supplied by Vicki de Kleer, Mollyhawk, Oakville, Ont.

Figure 1: Secure lines to bow and stern cleats with a large eye held with a splice or bowline.

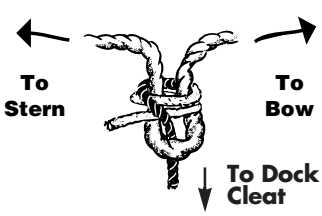


KNOTTY KNOW-HOW

Joining Two Lines

Use the **double becket bend** to join two lines together when one line has a bight (loop), as in our example above, or an eye splice. It holds securely in all types of synthetic ropes even when not under load.

First make a bight in the end of the first line, or in the center if making the dock-mate. The end of the second line or shorter dock line in the above example (colored with black and white stripes in our illustration), is passed through it, around the back of the two standing parts, across the eye, then under itself, passed around to the back and again wrapped around the standing parts. Finish the knot by threading the line under itself and pulling tight. When used to join two lines together with an eye, it is referred to as a double sheet bend.



ENGINE TROUBLESHOOTING

MARINE VERSUS AUTO: Accept NO Substitutions

If you drive a boat with a gasoline engine you should understand the potential for fire and explosions caused by non-marine electrical parts in the engine room. Engine compartments function much like a butane lighter: the engine room is the sealed housing; gasoline, fuel or propane vapors are the fuel; and ignition is provided by a stray spark from an alternator, starter or other "unprotected" electrical equipment.

Most boatbuilders and marine engine technicians are aware of the construction differences between marine and automotive electrical components. Electrical components installed in marine gasoline engine and fuel tank compartments must be ignition protected. This means they are sealed from the possibility of a spark when fuel or vapor leaks are present. Marine alternators have screens front and back. Distributors also have screens, caps are sealed and vents prevent condensation and rusting of the timing advance mechanism. Marine starters have sealing plates, sealed end caps and copper connectors instead of steel or aluminum used for automotive applications.

Production boats are quite safe until a component needs replacing. To substitute an automotive starter, distributor, alternator or other electrical part will definitely be easier on the wallet. Automotive suppliers sell reconditioned parts for 50% or less than marine. A rebuilt alternator, for example, costs $100. A new marine alternator — marine suppliers only sell new parts — costs $500. To save money, consider having the original marine part rebuilt by a qualified auto-electric shop. It's imperative that the shop is experienced with marine systems. Before installing any replacement electrical equipment, first ask about ignition protection.

Carburetors and fuel pumps are also specially designed for marine use. Carburetors in cars vent into the air filter or flood to overflow on the intake. Marine carbs vent internally and fuel floods into the engine. Jets are also different. Metering and power jets and power valves are all richer for marine use. A fuel pump on a car vents into the atmosphere and when it leaks, gasoline runs onto the road. If a marine fuel pump leaks, breather hoses fill up with fuel rather than going into the bilge.

TIPS Engines need an ample supply of fresh air to operate effectively. If the engine compartment becomes hot or strong fumes are noticeable when running the engine, install additional ventilation cowls.

Hoses are another area where automotive parts are often unknowingly substituted. Poor quality engine hoses deteriorate quickly from oil and heat. Before buying, check the hose rating and use a hose rated for the liquid it is supposed to carry. An exhaust hose rated for 82C to 93C (180F to 200F) may be adequate when the engine is running. Turn off the engine and heat from the manifold could raise the temperature to 232C (450F). Marine fuel hoses should have a burn rate of at least

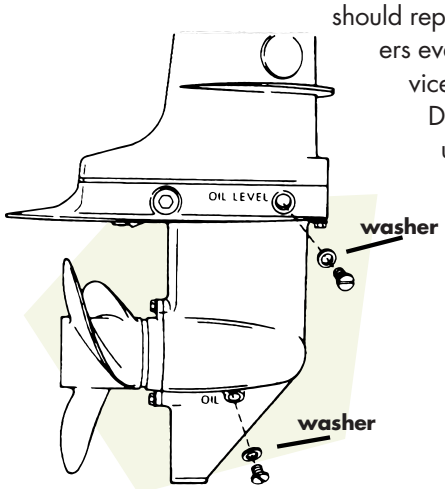
2 minutes. Automotive hoses are reinforced with steel and corrode. Rust particles end up in cooling passages or in the water pump and can cause extensive damage when installed in marine engines. Besides a risk to safety, incorrect hoses may void insurance or warranties.

OUTDRIVES
Milky Gear Oil = H_2O

Oil in the lower unit should be changed spring, fall and during the boating season depending on engine hours. When servicing the lower unit always inspect the color of the gear oil. Lubricant that has turned a milky brown indicates that water has entered the housing through a leaky rubber seal or gasket.

Worn vent screw washers, a failed water pump base gasket or shift shaft seal, bent or pitted propeller shaft are all areas where water seeps into the gear case. Most often, leaks are caused by worn or missing vent and fill screw washers. If you recently hit a submerged object, you may have unknowingly bent the prop shaft. A misaligned shaft "wobbles" as it spins, breaking seal contact and letting in water. Fishing line wrapped around the prop shaft also lets in water. If your engine is equipped with an aluminum prop and you recently cleaned off one or more blades, chances are the shaft is bent. Leaks must be repaired quickly; even microscopic quantities of water rusts bearings and wears gears.

For about $30, a marine mechanic can quickly locate the source of the leak by pressure testing your engine. Replacing vent and fill screw washers is a two-minute job: remove the screws, change the washer (.60 each) and refill the gear case. In fact, you should replace these washers every time you service the lower unit. DIYers may be unaware of this critical step, since washers are rarely stocked near gear oil, if at all, and owner's manuals fail to mention it. If water seepage is caused by a failed prop or shaft seal, you'll



Install new vent and fill screw washers with every oil change to prevent water contamination of gear lubricant.

need a Seal Kit. Normal wear and age causes rubber seals to harden. Acidic water also accelerates seal deterioration as does air: engines raised out of the water (typically, to avoid zebra mussels, barnacles or fouling) or stored on a boat and trailer harden faster than in water. As engine seals tend to fail at about the same rate, experts recommend replacing all of them. Seal Kits include seven or more seals (depending on the model) and two screw washers. Available from marine dealers, a do-it-yourself kit for a 150 hp outboard costs about $85. A dealer will charge for parts plus about 5 hours labor to do the job. After installing new seals, check that the propeller shaft is straight; a new prop seal won't hold if the shaft is out of alignment.

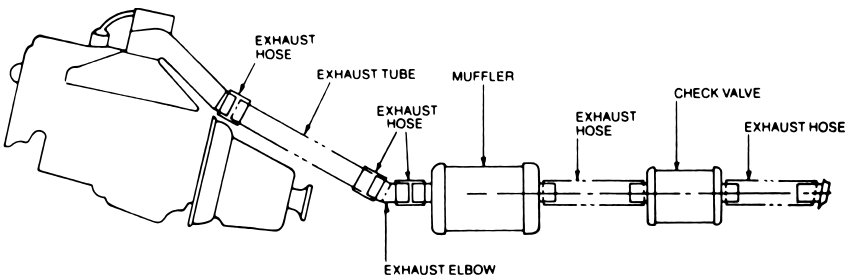
EXHAUST SYSTEM MAINTENANCE

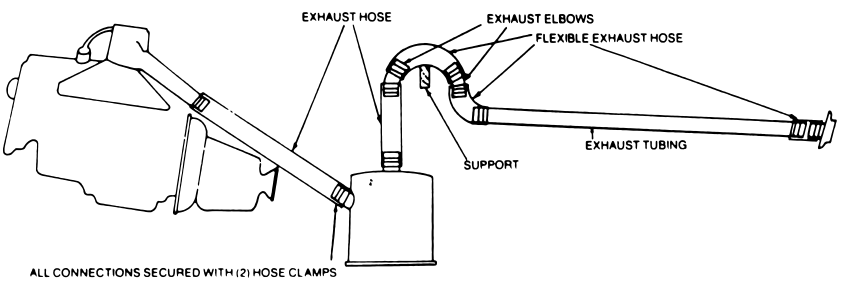
A properly maintained exhaust system is important to the overall safe performance and dependability of your boat's engine. Neglect this critical part of your powerplant and it can rob the engine of horsepower, growl excessively or cause fire, flood or even sinking.

The components in a wet exhaust system are hose, check valve (powerboats), exhaust elbows (sailboats) and a lift muffler. Sometimes referred to as a pot, water trap, waterlock or other generic name, lift mufflers are made of plastic, stainless steel, rubber and blends of these. If an exhaust system works well upon installation then you can count on having years of trouble-free service. With continued use, though, problems often occur from vibration that loosens a seal between components. An engine backfire or a blow from a heavy object may crack one of the pieces causing the engine compartment to flood with cooling water. Any leak in the exhaust system also lets potentially lethal carbon monoxide gases to ventilate into the boat.

There are several preventative measures to lessen the chance of damage and safety hazards. The entire exhaust system should be well supported to prevent damage from vibration. Heavy, water-filled exhaust tubes can easily break loose in rough seas if they are not properly secured. Double clamp all connections with stainless steel hose clamps and support hoses with cable ties to the hull. Check condition of hoses: deteriorated hose becomes brittle or dry and are spongy when squeezed. When replacing, always use high-temperature marine hose (see above). As part of your annual inspection, disconnect flexible hoses and check for carbon and salt buildup. This is especially critical on sailboats where engines are run for long hours at low rpm, building up excessive carbon deposits. Check the exhaust thru-hull fitting for water leaks and rebed if necessary. On sailboats, this fitting should be fitted with a seacock to prevent following seas from entering the exhaust system when the engine is not running. Replace any badly corroded components. Sailboaters need to regularly check the galvanized exhaust elbow for corrosion and carry a spare, especially when boating in saltwater.

Exhaust systems must slope downwards to prevent water from backing up into the engine. High-speed powerboats that quickly power-down should install an in-line check valve to prevent water flushing into the exhaust. On a sailboat, the exhaust hose must be looped high to prevent water backing up the hose and damaging the engine when heeled. When repowering a boat, size the exhaust system for the new engine or it will create power-robbing back pressure. Correct size is directly related to horsepower — the higher the horsepower the larger the components.





Whether you have a typical exhaust system for a powerboat (top) or sailboat (below), periodically check all components for cracks or leaky seals.

SAILBOAT
RIGGING

EASY SAIL CONTROL WITH A ROLL 'N REEFER

TOOLS

- Cable cutters
- Vise grips
- Hacksaw
- Needle nose pliers
- Pop rivet tool
- Assorted screwdrivers
- Wrench set
- Measuring tape
- Rigging tape
- Rags and solvent

Sail handling takes on new meaning with the installation of a furling system, the perfect solution for single-handed sailors or undercrewed boats. Besides simplifying sail handling, a furling system offers the convenience of reducing sail from the safety of the cockpit: you won't have to go forward to change sails. Hoist the #1 or #2 genoa once and if you're a cruiser, you will probably leave it up for the season or until it's in need of servicing.

Furling systems are available for trailerables up to 30m-plus (100') yachts. Trailerable owners have a choice of either the Flexible Furler from CDI, a time-proven system produced since 1979, or Harken's new 00 unit. Both models feature a one-piece flexible extrusion that is easily coiled for storing yet rigid when hoisted and prevents damage to the unit when raising or lowering the mast. For larger boats, there are a wide range of units available for both racers and cruisers.

COMPONENTS

The main differences in furling systems are largely in design and mechanics. When shopping for a furling system, you need to consider: extrusion, drum and bearing designs; ease of installation if planning to do it yourself; and price, especially if on a strict budget.

The two types of extrusions are round and airfoil (oval). The latter have less windage but tend to furl unevenly and loudly, producing a "Pfallup" sound when furling; round extrusions offer smooth furling without oscillation. Twin grooves provide racers with fast sail changes and when cruising are useful for flying twin headsails. Few cruisers will use more than one groove, opting to

Comparison of Jib Furling Systems

	Boat/Wire Size	Race/Cruise	Extrusion	Joint Assembly	Bearings	Drum	Prefeeder	Warranty	List Price
CDI	3mm-8mm	C	2/Airfoil	One-piece	Delrin	Fixed	None	Lifetime	$599+
Furlex	4mm-14mm	R/C	2/Airfoil	Connection springs	Stainless steel	Split	Std	5 years	$1,420+
Harken 00	22'	R/C	2/Round	One-piece	Torlon	Split	None	7 years	$895+
Harken	28'-80'	R/C	2/Airfoil	Screws	Torlon	Split	Std	7 years	$1,495+
Hood Seafurl LD	25'-80'	C	2/Round	Rivets	Stainless steel/Delrin	Fixed	Opt	5 years	$1,090+
Hood Seafurl SL	8mm,11mm	C	2/Round	Rivets	Torlon	Fixed	Opt	5 years	$1,195+
Profurl	6mm-25mm	R/C	2/Round/airfoil	Set screws	Carbon steel	Fixed/split	Std	5 years	$1,582+
Schaefer	3mm-14mm	R/C	2/Round	Rivets	Torlon	Split	None	5 years	$1,390+
Simplicite	20'-42'	C	1/Round	NA	None	Fixed	None	Lifetime	$495+
Ultra Furl	20'-50'	C	2/Round	Staggered extrusions	Stainless Steel	Fixed	Std	5 years	$1,370+

Note: Prices are approximate and in Canadian funds.

leave one sail on all season. Except for Furlex, all furlers slide over the existing forestay. (Furlex comes with a new forestay.) On many units, the turnbuckle also fits inside the drum so there's no need to cut the forestay and attach a new toggle.

Drums are either fixed or split. If you mostly cruise but enjoy club racing, consider a furling system with a split drum. Just remove the drum, tack the headsail on deck and the furler converts to a racing foil.

Bearings prevent wire chafe, reduce noise and corrosion and when properly set up, offer friction-free furling. A back-to-basics furler, like the lower-priced Simplicite furler, has no ball bearings or moving parts: the drum and upper washer ride on self-lubricating, graphite bushings. Moving up the scale, Furlex has stainless steel bearings, while Harken, Hood and Schaefer units use Torlon, a hardened plastic. These are all virtually maintenance-free bearings. A regular rinse with freshwater (more often for saltwater users) followed by a Teflon or moisture-displacing lubricant is all that's required. Ultra Furl units have a grease nipple on the drum. Profurl is the only system with completely maintenance-free, greased and sealed carbon-steel bearings, a bonus in saltwater. If bearings do corrode, however, the unit must be returned to the supplier. Because of the sealed bearings, Pro Furl systems are stiffer to roll.

Extrusion sections are joined together in myriad ways. Joints and bearings inserted into each foil section are held in place with a combination of springs, rivets, screws and glue. The exception is Ultra Furl: interlocking staggered joints slide together in minutes without any tools whatsoever. The assembly of extrusion joints and bushings greatly affects installation time and ease. The least desirable are pop rivets that require a pop rivet tool and must be drilled out if disassembling is necessary. Inserts and bearings also keep extrusions centered on the forestay and double as bushings between the stay and aluminum extrusion to reduce friction. Furlex has a full-length interior plastic sleeve to prevent extrusions from touching the stainless steel forestay, thus reducing the possibility of corrosion.

A note about prices.The more technological enhancements and features, the higher the price. Swivels and bearings all add to the cost as do independent upper and lower swivels that provide better sail shape when reefing. Packaged units may also cost more: Furlex and Schaefer come in a kit complete with everything you need plus the furling line, halyard lead blocks (Furlex), Sta-Lok terminal (Schaefer), locking adhesive and stanchion lead blocks for the furling line (Furlex). Other units require purchasing such components as required. Sailmakers often offer the best deals on all-inclusive packages (furler and sail conversions).

Sizing is based on diameter of the forestay wire or boat length. When your boat spans two sizes, select the one with the largest drum diameter; the smaller drum probably won't hold sufficient control line. When you are ready to purchase, the supplier will need to know one or more of the following: forestay wire size; turnbuckle diameter; and boat length.

TIPS

To make a perfectly straight cut on aluminum extrusions, wrap a piece of paper around the foil, overlap the ends, match the upper or cutting top edges and hold in place with masking tape. Mark the cutting line with a pen or pencil.

SAILBOAT RIGGING

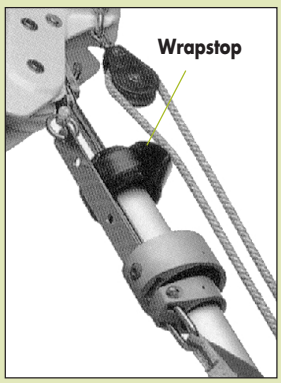
OPTIONS

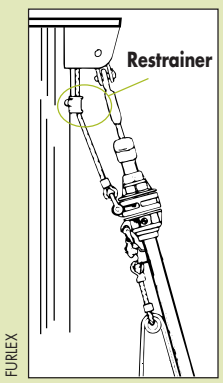
Options include link plates, prefeeder and furling control line (included with Hood, Furlex and Schaefer). Available in two sizes, short and long, link plates raise the furling drum off the deck. The long plate places the drum at pulpit height, about 45cm (18") higher. Concerned with sacrificing performance, few boaters opt for link plates but the benefits are many: easy turnbuckle inspection and adjustment; easy access to anchors and less possible damage to the drum should the heel kick up; and for cruisers, better visibility under the genoa and less chafe of the foot on the pulpit. Standard on some units, a prefeeder should allow hoisting the sail from the cockpit without going forward. Depending on the design, luff tapes may still snag and require feeding from the bow. Furling control lines are

Troubleshooting Furling Systems

Operating difficulties with furlers are generally caused by improper or incomplete installation and sail fit. In most cases, problems are caused by one or more of the following: halyard wrap; insufficient or excessive headstay tension; halyard tension; furling line jamming; and dirt or salt in bearings (except units with sealed bearings).

Halyard wrap is when the halyard wraps around the forestay when furling. It's caused by either incorrect positioning of the halyard swivel, which is controlled by sail luff length, or wrong halyard angle. When the upper swivel sits is too far down from the sheave the halyard wraps around the forestay. The distance varies with each model. Check installation manual for the exact height. To correct a low swivel, attach a wire pennant to the head or tack of each sail used on the furler. When attaching to the tack, the pennant must not put the bottom of the sail below the feeder. Halyard wrap is also caused by the angle between the halyard and the forestay. As many halyards exit directly below the forestay, both run parallel to each other. To operate effectively, the halyard angle must be canted slightly aft between 5 and 10 degrees, depending on the furler. If the angle is less, you'll need a halyard restrainer ($30) to "pull back" the halyard. This small block attaches to the front of the mast, about 10.1cm (4") below the sheave box. After exiting the sheave, the halyard passes through this block increasing the angle of attack on the forestay. Another option is to mount a sheave box just below the masthead and relead the jib halyard. This takes longer but gives a more direct lead. Profurl units have Wrapstop, an anti-wrap device that prevents the halyard swivel from rotating regardless of the tension or angle and also keeps the spinnaker halyard (which is higher than the jib) clear of the swivel. Ultra Furl has an integral halyard fitting to eliminate halyard wrap.





PREVENTING HALYARD WRAP: A restrainer (across) repositions the halyard aft of the forestay and wire head pennant raises swivel height. Profurl's Wrapstop (top) prevents halyard wrap and jamming of spinnaker or spare halyards.

Insufficient forestay tension and excessive sag result in rough furling that creates a "Pfullup" sound. If your boat is not equipped with a backstay adjuster, you'll need to install one to maintain tension while furling. If the mast hooks after tightening the backstay, release it and loosen the mainsheet, vang and shrouds if necessary, take up on the forestay, then retension the rig.

If there is tremendous force on the control line when furling, you probably have too much halyard tension, especially if you just tightened the backstay. To check, simply easy off slightly on the halyard and furl. After adjusting, check placement of the halyard swivel. Halyard tension has no control over luff sag with a foil system; use the backstay instead.

When the furling line does not exit at the correct angle, you will get overriding turns on the drum, causing the drum to jam before the sail completely unfurls. Place the forward lead block so the control line exits at about 90 degrees to the forestay (see *Installation*). Furlex and Ultra Furl have an adjustable line feeder that lets you set the angle of the control line to the forestay.

Dirt and salt accumulation inside exposed bearings cause abrasion and premature wearing. Regularly clean bearings then spray with a moisture-displacing lubricant. It's good practice to carry spares of extrusion joining screws, springs, shackles and other parts that have a tendency to land on deck when you least expect it.

usually polyester braid, 6mm (1/4") in diameter. Often the line on the drum is decored, giving a flatter, more compact coil.

INSTALLATION

While most owners opt to have their supplier install the furler, many systems are easily owner installed. Do it yourself and you'll save about $300. Installation should take about four hours, depending on: whether you need to replace the existing forestay or turnbuckle; cut and splice the wire if installing link plates; your level of expertise; and the possibility of a chance visit from Murphy. Don't be bamboozled by manufacturer's literature declaring quick one-hour set ups; experience suggests otherwise. Any installation that requires cutting the forestay and splicing it in the drum to a Norseman or Sta-Lok fitting is time consuming. When rod is involved, which must be cut and reheaded, requires the services of a rigger.

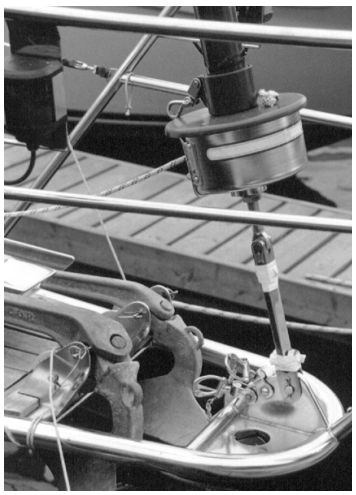
Most installations require removing the forestay from a stepped mast (keel or deck). Before doing so, first run one or two jib halyards forward and tie to a tack fitting on deck, mooring cleat or other secure fitting. (Do not attach with a snap shackle if the halyard end is so equipped.) To lower the forestay, go aloft in a bosun's chair and fasten a spare jib or spinnaker halyard to the upper toggle, then lower. Once on shore, unpack the furler, check all pieces against the equipment list and carefully place on plastic or newspaper. If you need to cut the forestay or if using a new forestay, check the installation manual carefully. Remember: measure twice, cut once. Tension the forestay then measure, wrap wire with rigging tape to prevent unraveling and cut through the tape using a hacksaw. In both cases, you'll need to add a swage, Norseman or Sta-Lok fitting. The latter two are easily owner installed; a swaged fitting requires the services of a professional rigger.

Some systems are installed without detaching the forestay. Simply slip the masthead stop around the forestay, attach a tape measure, genoa halyard and messenger line to this stop (use masking tape), and hoist it to the upper toggle or swage. Check that the tape measure is without kinks, then take a reading. Subtract allowances for a turnbuckle, lower swivel and other hardware as outlined in the installation manual. Beginning with the uppermost piece, slip hardware over the forestay, followed by the extrusion sections in the correct order (top first). To take up the weight of the lower drum, use a spare halyard (if you have one) attached to the drum's tack fitting and hoist into position.

Regardless of the installation method, you will need to cut one extrusion (usually the bottom of the top extrusion) to the correct length. Double check all measurements before cutting the foil. Wrap a scrap of paper around the extru-

SAILBOAT
RIGGING

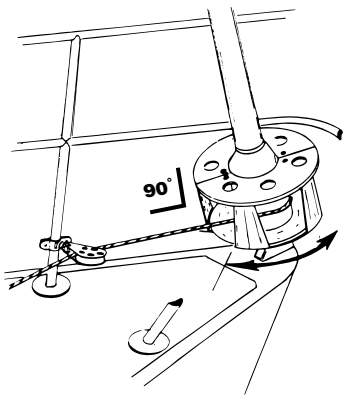
sion so the the ends overlap and top or cutting edge is perfectly matched, then tape ends. With a pen or pencil, mark the edge and cut with a sharp hacksaw. File or sand the cut edge smooth with emery cloth. Assemble the furler, carefully following the instructions. To prevent screws hold-



J. MUNDY

Optional link plates raise the drum off the deck reducing sail chafe and simplify anchoring.

ing extrusion joints and bearings from backing out, bed each in Loctite or similar locking adhesive before fastening. Wipe up excess adhesive with acetone. Once all components are assembled on the forestay, reattach it to the mast and tack fitting then tension the turnbuckle. This demands lots of extra hands to support the weight and prevent extrusions from bending; do not attempt this in strong



SCHAEFER

Position the forward lead block so the control line exits at 90 degrees to the forestay.

winds.

Wind the furling control line around the drum. As a rule of thumb, this line measures the length of the boat plus the foot of the sail. One exception, the Hood Sea Furl LD, has a continuous furling line: furling in one direction and unfurling in the opposite. Lines travel down each side of the boat, requiring twice the length plus additional lead blocks. Lead the control line aft to the cockpit. Use lead blocks attached to stanchions or mount stand-up blocks (blocks with springs) to the rail or padeyes on deck. On boats under 10.5m (35'), it's not necessary to lead the line to a spinnaker or main halyard winch, although it's an advantage in a blow.

Do a dry run at the dock to ensure all pieces are assembled correctly before hoisting the sail. Now hoist the sail on a windless day, walk down the dock and using binoculars, have a crewmember slowly furl the unit while you inspect what's happening at masthead. If there's any friction when furling or you see the halyard wrapping around the forestay, STOP immediately. Do not put the furling line around a winch and pull it or you risk breaking the forestay or extrusions. Check your manual to ensure correct positioning of the halyard swivel and angle of the jib halyard (see Troubleshooting).

SAIL CONVERSIONS

Converting a headsail to furling involves removing hanks, resizing, rebuilding the tack and head patches and installing new luff tape. To improve sail shape, some sailmakers recommend adding a contoured foam luff tape. A topic of much debate, this tape is designed to reduce draft (flatten the sail) when reefed, especially with used sails that are generally fuller. Standard on sails for boats over 9m (30'), it adds about $1 per foot of luff length to the conversion bill. On smaller boats, try using the sail without tape; if it doesn't roll well, then invest in the foam tape.

As sailcloth has no ultraviolet (UV) inhibitors and will breakdown in sunlight, the leech and foot must be protected. It takes from two to five years depending on the quality of the original cloth, before UV rots Dacron. You have two options: a UV-treated Dacron or acrylic strip. Dacron is lighter and being of a similar material, also gives additional reinforcement. Acrylic stretches more and comes in a wide range of colors. These strips measure about 45cm (18") wide and are sewn on leech. Both cost less than $6 per foot. A protective sleeve made of acrylic is another option. Fitted with a full-length zipper it slides over the furled sail; these tend to flap in the wind causing excessive vibration. The average cost to recut, add standard luff tape and a UV cover on a genoa that fits a 8.1m- (27') boat is about $500.

OPERATION

Furling systems are simple to operate. To unfurl, release the control line while pulling the genoa sheet. Keep tension on both lines to prevent overriding turns on the drum. To furl the sail, release the jib sheet, keep light tension on the line and pull in the control line. When using the furler for reefing, luff up, ease the sheet while maintaining tension and pull the control line. When the desired amount of sail is furled, securely cleat the line. If furling is difficult, try easing halyard tension but not too much as to affect sail shape. Move the genoa sheet leads forward to maintain correct foot and luff tension.

Albeit sails designed for reefing are cut flatter than a genoa with hanks, reefing compromises both sail performance and durability. It's difficult to match one sail to a broad range of wind conditions. A light weather sail reefed in strong winds, for example, quickly lose its shape. A mid-range #2 genoa gives much better performance when partially furled and better sail shape than a #1, without sacrificing a lot of area. When reefing, try matching sail area to wind conditions up to a #3 (100%), depending on the boat. A better solution is to install an inner forestay for working and storm jibs (see *Sailboat Rigging* in FALL '95 issue).

To prevent the sail from unfurling when stored on the furler, take a few extra turns on the furling line so the sheet wraps around the sail several times. It's also advisable to tie a separate line around the sail and secure the drum with a line fastened to the rail or a cleat. If the control line is accidentally released, the sail cannot unfurl. When the furler is not in use, it's recommended you slacken the halyard to reduce luff tension.

DIY PROJECTS

BOAT REFIT

Take advantage of the off season and increase comfort, convenience or safety on board with these do-it-yourself projects for renovating interiors, decks and cockpits.

Illustrations by Anne-Marie Hendry

STORAGE SOLUTIONS

A great way to organize your clothes and gear both in the cabin and cockpit is to make storage bags of canvas or sailcloth. Cockpit bags snap to a bulkhead and keep binoculars, spare lines, fog horn, flashlight, "dog bags," sun screen and sunglasses within an arm's reach of the helm. A duffle-type bag that snaps to a bulkhead or fastens to the cabin sides or ceiling with Velcro keeps clothing, gear, tools and knickknacks handy and dry.

J. MUNDY

Cockpit storage bag made of Dacron sailcloth keeps loose gear near the helm.

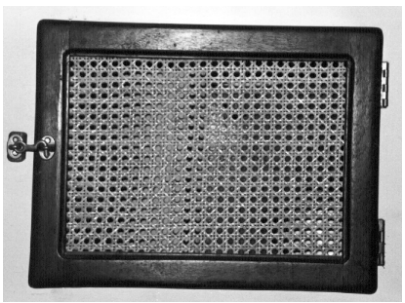
Canvas bag mounts on teak bulkhead with turn button-type fasteners.

Storage bags can be any shape: round, oval, rectangular, flat or with pleats that expand when stuffed. Cut from scraps of acrylic, canvas or medium-weight Dacron sailcloth, allow 19mm (3/4") seams on the sides and 2.54cm (1") double-wide helm on the top and bottom for reinforcement. Leave the top open or close with a plastic zipper or Velcro. Bags attach to a wood, fiberglass or fabric-covered bulkhead or cabin sides with dome or turn button-type fasteners. If using the latter, use a stud end with screw base and bed fastener in sealant for a watertight seal. Velcro easily adheres to many interior fabrics or you can glue on a strip. Punch grommets in bottom of cockpit bags for drainage.

SCREENS FOR LOCKERS

Most storage lockers in boat interiors are poorly ventilated, trapping stale air that forms condensation as it cools. As condensation builds, mildew accumulates, leaving telltale yellow powder or black stains on charts, clothes and other gear. Increasing air flow is easily remedied by replacing solid locker doors with front "screens" made of cane. Besides being practical, cane and wood adds to the ambience of an all-glass interior. It's simple to do and materials to cane one locker will cost you under $20.

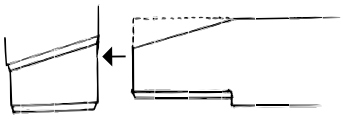
The first step is to make a wooden frame. Measure the outer dimensions of the locker and purchase enough finished teak or mahogany stock, 6.3cm- (2-1/2") wide and 19mm (3/4") thick plus 12mm (1/2") molding of the same length.



Replace locker door fronts with cane "screens" to reduce condensation and improve air flow.

Make one large door frame or opt for two smaller ones that fasten in the middle. Cut the frame so it overlaps the locker perimeter by half its width. Mitre **(Figure 1)** or end lap the corners **(Figure 2)**, assemble with epoxy glue and clamp (use bar clamps) in position. When dry, round the edges with a router. Cut the molding so it lays on the underside of the frame, 3.1cm (1-1/4") in from the outer edge, butting or half-lapping the corners. Dry fit and drill

Figure 1: Off corner mitre join.



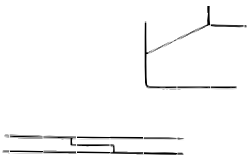
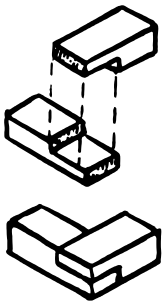


Figure 2: End lap.



Frame Corners

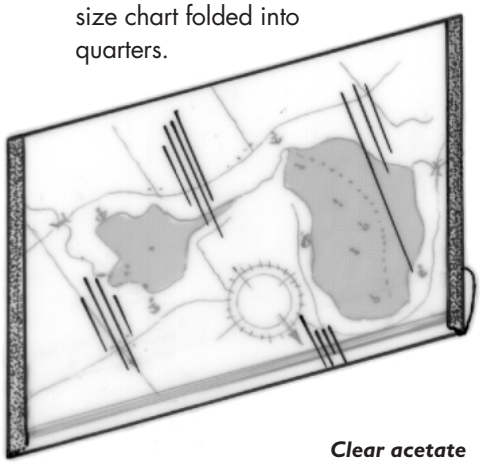
holes for 19mm (3/4") #6 brass screws, spaced about 10.1cm (4") apart. When assembled, the molding holds the cane in place and gives a finished edge. Put the molding aside for now.

With the frame completed, you need to apply the cane. Purchase machine-made cane just slightly larger than the frame. Soak it in water for two minutes or until it's pliable. Apply a thin bead of thickened epoxy glue to the frame where it comes in contact with the molding, and to the underside of the molding. Towel dry the cane, then lay it over the wrong side of the frame. Make sure the pattern runs parallel to the frame edge. Lay the molding over the cane, lining up the screw holes. Working from the top edge, stretch the cane as much as possible and secure with screws. Continue stretching and fastening until all sides are fastened. Use C-clamps to hold molding and cane in place if needed. Wipe up any excess glue and trim cane edges with a utility knife. When the cane dries, it becomes taut and surface irregularities disappear. Once fully dry, apply varnish to the frame and spray cane with a non-gloss shellac to block any moisture absorption. Attach door with brass hinges and fasten with a hook and eye.

Professional builders use an alternate method: rather than gluing on a molding strip, a groove routed in the underside of the frame accommodates a narrow caning bead that when forced into place, stretches the cane, but our method is simpler and just as effective.

WATERPROOF CHART HOLDER

Like most "necessities" these days, the cost of navigation charts goes up every year. Unless you don't mind frequently replacing charts, you need to protect them from rain, spray, accidental drink spills, sand or even mildew when in the cockpit or stowed below. This waterproof holder will keep charts dry, clean and protected from the usual wear and tear. Made of clear acetate, the same stuff used for windows in tops, biminis and sails (available from marine canvas shops), you can mark navigation information on the outside with a grease pencil. It takes about 20 minutes to make and fits a full size chart folded into quarters.



Clear acetate holder protects charts and you can write on the outside with a grease pencil.

DIY PROJECTS

You'll need a piece of acetate 63.5cm by .9m (25" by 39") (**Figure 3**). Measure 45.7cm (18") from one end and fold, creasing edge with ruler or scissors. This gives you a 7.6cm (3") overlap on the other end. Seal both sides with waterproof tape; duct tape will breakdown when exposed to sunlight. Crease the top edge along the fold line to form a flap. Store your chart in this holder and keep in the cockpit or on the dash, close at hand.

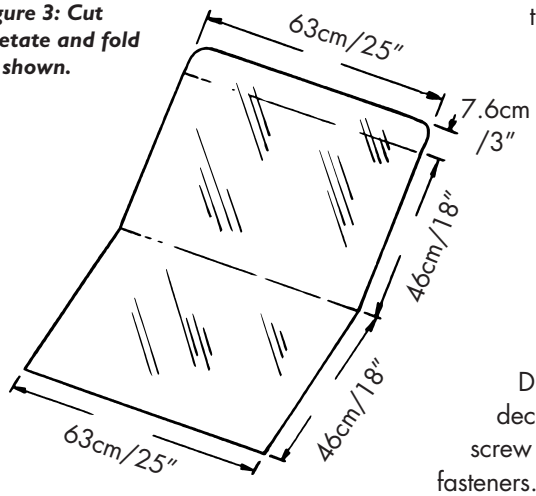


Figure 3: Cut acetate and fold as shown.

LIGHTEN UP

Brighten dark forepeaks, lockers or aft cabin areas with a prism. Made of break-resistant glass mounted in a polished bronze or stainless frame, it disperses a wide beam of natural light. A prism's only drawback is the added weight: a 7.6cm by 25.4cm (3" by 10") prism adds nearly 3.15kg (7 lb).

Carefully measure the outside cutting dimension of the prism's mounting flange and transfer same

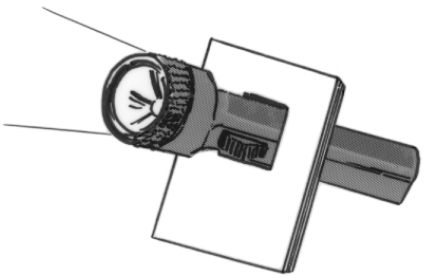
J. MUNDY

"Natural" light from a prism brightens forepeaks, lockers or aft cabin areas.

to the deck. To cut a square hole with a jigsaw, first drill a 8mm (5/16") hole in each of the four corners, positioning the blade so it dissects the vertex. Insert the saw blade in each hole and cut along the vertical or horizontal line to the corner. Reposition the blade in the connecting hole and continue cutting. When completed, you will have a square cutout with perfectly matched corners. Dry fit the prism and file deck cutout to fit. Mark screw holes and drill. Dry fit fasteners. Clean all surfaces with solvent, coat inner flange of prism and deck with polysulfide sealant and screw in place. Tighten until sealant oozes out, leaving a 3mm (1/8") gap between matting surfaces. Remove excess sealant with a putty knife and finish with a solvent-moistened cloth wrapped on the end of your finger. Mount a finishing ring on the interior deckhead, if desired.

NO-HANDS FLASHLIGHT

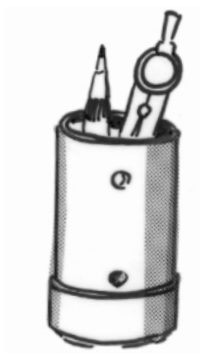
Some of the most practical devices are the simplest. This flashlight stand lets you direct the light where you need it most and prevents the flashlight from rolling away when you set it down. It costs less than $1 and takes about 20 minutes to make. Start with a water-resistant flashlight. Then take a piece of strap Plexiglas or plywood, 6mm (1/4") or smaller, and cut into a rectangle using a jigsaw. Cut a hole the diameter of the flashlight near the bottom and offset to one corner. Mount the flashlight and tape in place if necessary. Rotate the stand to adjust the angle of the light beam as required to illuminate your work.



Hands-free flashlight holder.

PVC ORGANIZERS

PVC pipe offers an inexpensive and secure means of storing a boathook, spare anchor, mop, fishing rods, winch handles, tools, navigation utensils, pencils, cutlery or dishes. Lightweight and waterproof, it's virtually indestructible and won't rot. Available from plumbing supply stores and some hardware stores, PVC comes in white or black in a broad range of diameters. Easy to work with, it is simply cut with a hacksaw and the rough edge filed smooth.



Utensil container

Here are just a few of the things you can make with PVC. Use hose

Anchor holder clamped to stanchion.

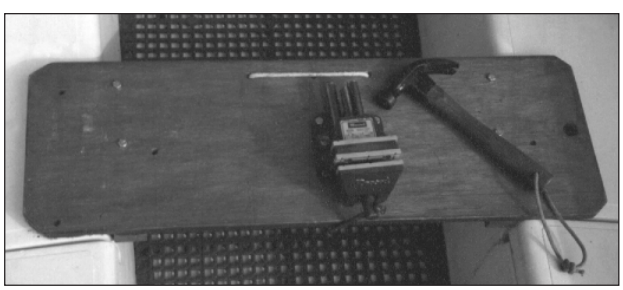
clamps to attach holders to stanchions or the pulpit, or fasten with stainless steel screws to bulkheads. For utensil containers, glue an end cap onto the bottom. When mounted on deck, drill a drain hole in the bottom. To make a cup holder, take a 25.4cm (10") length of 10.1cm (4") diameter PVC, cut a slot in one side, stopping about 3.8cm (1-1/2") from the lower edge so the first cup is not suspended by its handle but rests on the bottom. Glue on an end cap, then drill holes for bolts or screws on the back if mounting on a bulkhead, or on the bottom for attaching to a countertop.

Cup holder.

COCKPIT WORKBENCH

Every DIYer knows the importance of a good working surface when doing maintenance or repairs and unless you have a very large boat, the majority of boats are without. Vicki de Kleer's solution was to design a portable workbench for her Contessa 26 moored in Bronte Harbour, Ont.

Made of 19mm (3/4") plywood, it slides into the opening between the cockpit seats. It should be at least 35.5cm (14") wide. The length equals cockpit width plus an extra 15.2cm (6") per side overhang. Narrow, full-width plywood pads on the underside fit between the cockpit sides and are slightly V-shaped; the back edge is narrower than the front so the table self-clamps when slid into place. Carpet glued on the underside

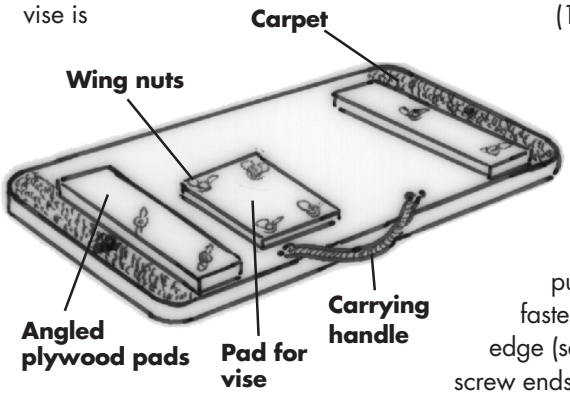


VICKI DE KLEER

Cockpit workbench with small vise bolted in place.

DIY PROJECTS

overhanging edges prevents marring the deck. A small plywood pad glued underneath, reinforces the area where the vise is



Underside of workbench shows V-shaped plywood pads, carpet on overhanging edges, plywood reinforcing pad for vise and carrying handle.

mounted. Holes are drilled through both layers using the vise as a pattern. When needed, the vise attaches to the workbench top with bolts and wing nuts. A rope handle makes it easier to carry. When not in use the vise stows in a locker; the bench is lashed to the underside of a floorboard.

KEEP GEAR IN ITS PLACE

Bunkboards (also called lee cloths) were traditionally designed for sailboats, to keep sailors from falling out of their berths when underway. For everyday use on any power or sailboat, bunkboards prevent duffle bags, clothes and other loose gear stored on dinette seats or berths from being tossed about the cabin in a rough sea.

Made of medium weight cotton canvas or acrylic, this removable bunkboard snaps to the inside of the searail, if equipped, or wraps under the cushion and snaps to the settee or berth top. When not needed, it folds into a compact package to stow neatly in a locker. For one bunkboard, you'll need enough fabric to give a finished height of at least 35.5cm (14") and 30.4cm (12") shorter in length at each end than the berth or settee (see **Figure 4**). The exact height and length depend on cushion thickness, method of fastening and berth length. Also purchase enough dome fasteners to hold the bottom edge (see below) and studs with screw ends, rope, two boat snaps and two pad eyes.

After determining the size, cut the fabric plus an extra 5cm (2") seam allowance on all sides. Taper the sides at a 45-degree angle to the bottom. Sew all edges, turning under 2.54cm (1") twice to form a double-wide hem. Attach button caps to the fabric, spaced every 20.3cm (8") or so. Punch a large grommet in the top of each corner.

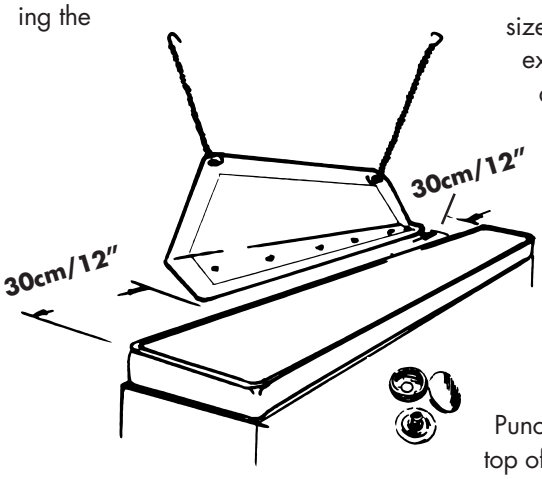
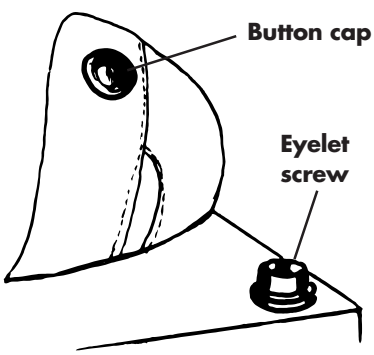
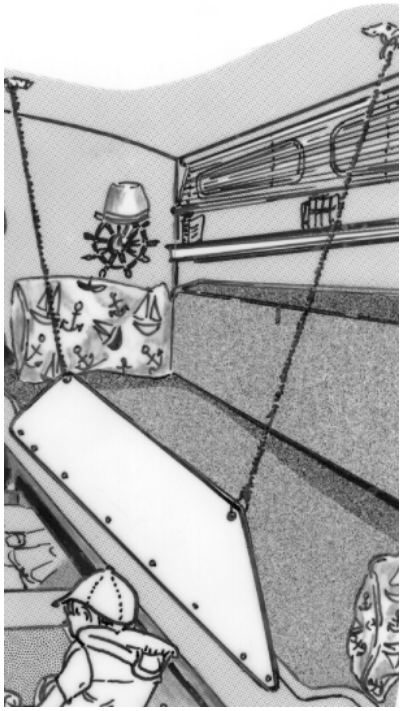


Figure 4: Bunkboards are cut smaller than the berth or settee and snap in place with dome fasteners (Figure 5).





Keep loose gear in its place with easy-to-make canvas bunkboards.

To assemble, lay the canvas over the berth, stretch slightly, and mark fastener placement. Drill pilot holes for the eyelet screws where they attach to either the settee or berth top surface or inner face of the rail (**Figure 5**). Knot or splice a length of rope to each grommet. Hold the rope and raise the bunkboard in position, lifting up at a 30-degree angle or so. Make a mark where each rope touches the ceiling and mount small pad eyes. Cut the rope to fit and tie a boat snap to each end.

ADD A CUPBOARD

Boats never have enough cupboards for storing small items in readily accessible yet out-of-the-way spots. This cupboard, designed by Arild Jensen, Beaverton, Ont., for his Sirius 21, has two shelves and fits neatly between the companionway and the cabin aft bulkhead. The frame is made of 12mm (1/2") mahogany, teak or cherry; the doors of 6mm (1/4") mahogany or teak veneer plywood.

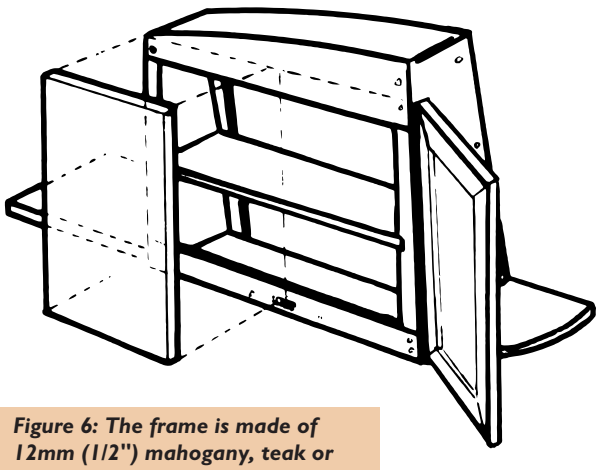
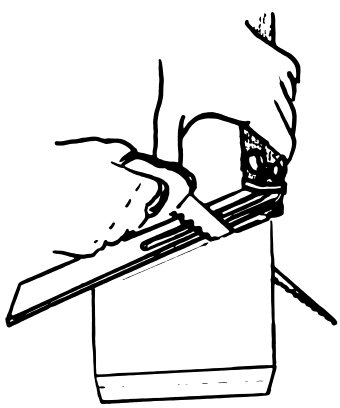


Figure 6: The frame is made of 12mm (1/2") mahogany, teak or cherry; the doors of 6mm (1/4") mahogany or teak veneer plywood.



Use a bevel gauge to measure the deck and bulkhead angles then transfer to stock before cutting.

To get the proper dimensions, first make cardboard templates. Hang a plumb line from the ceiling to establish the vertical front edge of the cabinet. Depth varies, depending on the space available. This cupboard measures 68.5cm (27") long, including the overhanging lower shelf, 40cm (15-3/4") high and has a maximum depth of 16.5cm (6-1/2"). The two doors are 35.5cm (14") high and each is 20.3cm (8") wide. Cut patterns for the sides, bottom (lower shelf) and front header

ARILD JENSEN

This cupboard fits neatly between the companionway and the aft cabin bulkhead.

piece, using a very sharp utility knife to get clean, straight edges. Use a compass with a pencil to strike the cutting lines. The angled bulkhead and deck camber require careful fitting. Assemble the pieces (see **Figure 6**), using masking tape to hold it all together. Continue fitting and cutting until the shelf fits perfectly.

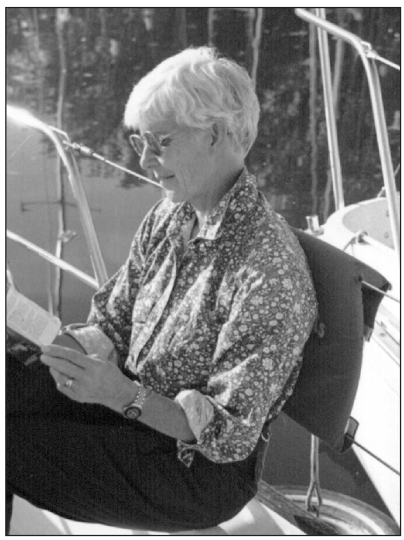
Trace templates onto the wood, being careful to allow for the difference in cardboard and wood thickness when designing joints. Before cutting, measure the deck and bulkhead angles with a bevel gauge and set the saw blade accordingly. Cut extra cleat stock about 2.54cm (1") wide. These get screwed to the bulkhead and support the cupboard sides and bottom shelf. You'll also need to cut a fiddle rail that mounts on the front of both shelves (only the bottom one has a rail in the drawing). Cut a narrow 12mm- (1/2") wide groove in the ends, on the inside, to support the center shelf.

Glue and screw the cleat stock to the bulkhead, 12mm (1/2") inside the shelf's outer dimensions. Assemble the sides and bottom shelf using glue and brass or stainless screws. To hide the screw heads, countersink the holes and tap in bungs for a more professional look. Dry fit cupboard to the cleat stock before attaching center shelf and fiddle rails. When all is in place, mount the header piece.

For the doors, insert plywood into a saw kerf in the door frame using conventional picture frame construction or build a solid plywood door of 16mm (5/8") plywood.

Use thicker plywood so it doesn't warp. Finish with three or four coats of oil or varnish. Attach four brass hinges and a stud catch on the bottom.

BACKREST FOR SAILORS

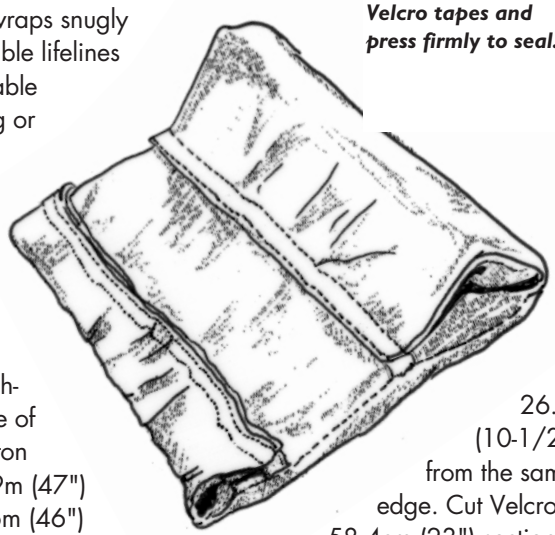


J. MUNDY

As a rule, sailboaters lack the comfortable seating amenities that powerboaters have grown accustomed to. There are no thickly padded seats with lumbar supports, backrests, lounges and the like. This lifeline cushion wraps snugly around standard double lifelines and offers a comfortable backrest when sailing or berthed in port relaxing with a good book. Anyone who can operate a sewing machine can easily make this cushion.

To make one cushion purchase: a piece of acrylic or treated cotton duck measuring 1.19m (47") by 66cm (26"); 1.16m (46") of 2.54cm- (1") wide Velcro, both hook and loop; and a 57.7cm (22-1/2") by 38.1cm (15") piece of 2.54cm (1") medium-density foam. (Do not use closed-cell foam, it's much too hard.) Finished size measures 58.4cm (23") wide by 60.9cm (24") high.

Construct the cushion as follows (see **Figure 7**): Turn under the ends 12mm (1/2") and crease with scissor points or baste in place. On the back side, measure 11.4cm (4-1/2") up from the lower edge and draw a straight line with a chalk pencil along one half of the fabric (right side out). Draw a second line



Fold cushion, line up Velcro tapes and press firmly to seal.

26.6cm (10-1/2") from the same edge. Cut Velcro into 58.4cm (23") sections.

Sew two pieces of loop tape to the fabric, matching the outer edge against the drawn lines. Now, fold the fabric in half, right sides together and sew a 12mm (1/2") seam along the bottom and side. Turn the fabric right side out and working on the back side, sew hook

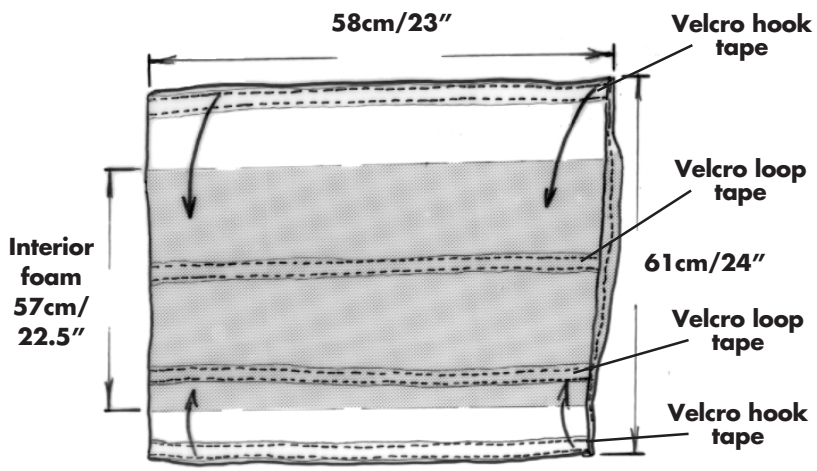


Figure 7: Underside of cushion showing placement of Velcro and foam.

DIY PROJECTS

tape to the bottom edge, matching the outer edge of the tape with the fabric finished edge. Now, stitch a straight line 7.6cm (3") up from the bottom edge; this holds the foam in place. Stuff foam inside the cushion and close the top edge by turning under a 12mm (1/2") hem. Machine baste in place. Sew the last piece of hook tape to the top, matching edges. To use, wrap the top around the upper lifeline and fasten. Ditto for the bottom, tensioning the bottom lifeline, if necessary, until the Velcro hook and loop mesh.

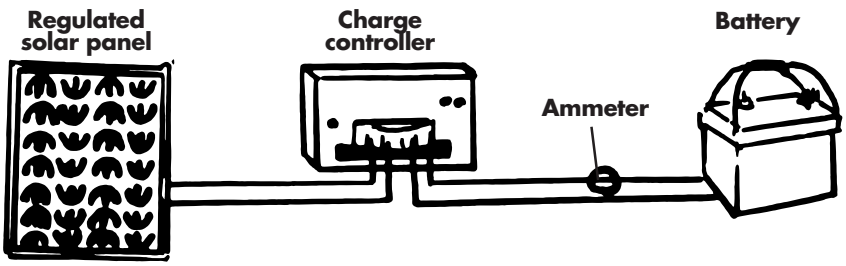
Now lean back and enjoy!

POWER FROM THE SUN

Solar panels offer an inexpensive solution to a boat's energy needs. Designed to convert light energy directly to battery charge current, a solar panel mounted on deck will keep batteries fully charged between cruises or during winter storage (if stored on board). Besides eliminating dependence on shore-power and plug-in chargers, solar charging extends battery life. Maintaining correct voltage more than doubles battery life.

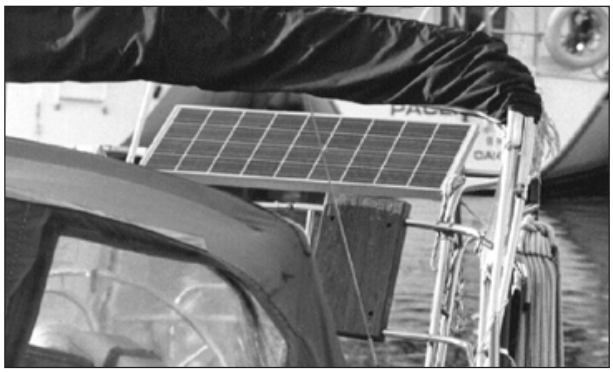
All solar panels are rated in watts and measure either peak or maximum output rating, or a degraded long-term stable rating. The latter is lower yet a more accurate measurement of a panel's performance. (Convert to amps by dividing by the boat's voltage, either 12, 24 or 32.), A 17-watt or 1.0-amp panel, installed in a 12-volt system, keeps batteries charged and provides adequate power for lights and DC appliances without running the engine or a charger connected to land. Multiple solar panels, connected in parallel, produce even more power, providing battery capacity is large enough to accept the increased current without overcharging. A safe rule of thumb is 50 amp-hours of battery capacity per amp of charger current. Solar systems require quality deep-cycle batteries for storing power. In multiple battery installations, installers usually recommend 6-volt golf cart batteries. These last longer and have deeper discharge capabilities. Also, an accurate analog or digital ammeter lets you verify the charger is working (every boat should have one!).

Portable (flexible) and fixed (hard) solar panels in varying capacities and sizes are available from PulseTech, Siemens, Solarex, United Solar and others. Flexible units are unbreakable, some float, and most have corner grommets that fasten with screws or ties to a dodger, deck or dash. These are easily relocated to achieve maximum exposure to sunlight. Hard models are permanently mounted on a horizontal surface that gets clear, unobstructed sunlight — davits, between stanchions, radar arch or on deck. Solar panels run "hot." When installing, allow air circulation around the panel for cooling.



Single solar panel installation with a charge controller.

Easy to install, a basic solar system comes with a power cable, battery terminal connectors, built-in fuse and diode (optional). Use marine-grade wiring and crimp-on, heat-shrink terminals to protect against corrosion. Wire size depends on the total amperage of the system and the distance between the panels and battery. For example: two solar panels with a total output of 6 amps, 7.5m (25') away from the batteries, requires a minimum wire size of 12 AWG.



J. MUNDY

Solar panels eliminate dependence on shorepower and plug-in chargers and extend battery life.

Smaller panels of 14.6 volts or less are safely wired directly to the battery. A fuse on the positive wire near the battery prevents a short in the system that likely will cause a fire. A blocking diode, optional on some systems, also connects to the positive wire to prevent any current flowing back to the panel after dark and discharging the battery. When installed it reduces rated output by about .6 volts. Without a diode, panels loose as much as 1/4 amp during the night. It's an insignificant amount in a 17-amp panel but accounts for a lot of energy in a 5-amp panel. Higher voltage panels (15 to 17 volts) require a charge controller or regulator, which incorporates a fuse and diode to avoid overcharging the batteries when the boat is unattended. While many regulators are designed for high-output panels, the Flexcharge NC25 charge controller can be used on systems as small as 0.1 amps of charging source output. It works independently or in any combination with either solar, wind or outboard charging systems for larger installations. It uses minimal power to operate, about .2% of the charging current, making it considerably more energy efficient that a diode when installing smaller capacity panels.

Solar panels produce more output in cooler northern climates than in the hot tropics due to the operating characteristics of the solar cells. The black body of the photo voltaic cells absorbs a lot of solar heat. This heat buildup reduces the efficiency of energy conversion. When purchasing a panel, take note of the output reduction in high temperatures as some panels drop 20% or more. Regardless of the unit, a charge controller is essential for boats operating in tropical climes.

The amount of power delivered to your battery depends on mounting, battery state of charge and weather. Most units will begin to charge in as little as 10% of bright sunlight.

While solar power may not be the most economical source of energy it certainly is very practical for remote locations away from shorepower or motor-driven chargers. Prices start at about $50 for a float charger, but can run into the hundreds.

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REJUVENATE WORN INTERIORS WITH NEW CUSHIONS

Materials

Upholstery material
Plastic zippers (optional)
Polyurethane medium-density foam
Polyester batting
6mm (1/4") cable cord

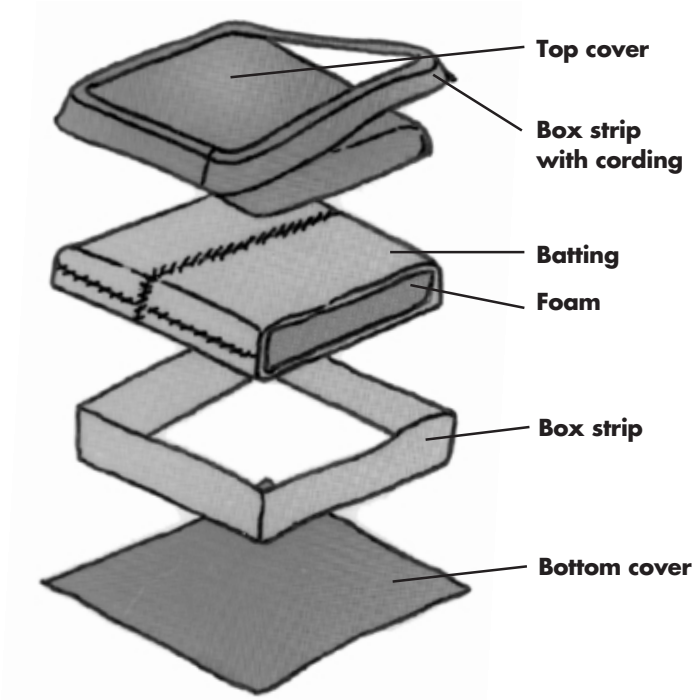
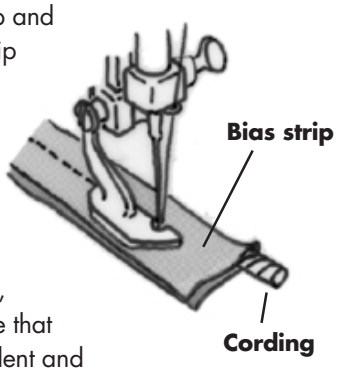
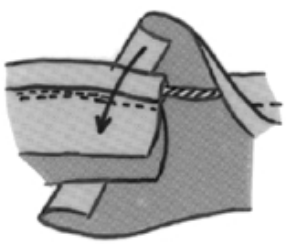


Figure 8: A basic cushion consists of bottom and top covers, box strip the width of the cushion, cording and foam wrapped with polyester batting (optional).

Nothing can enhance the ambiance in a cabin quite like new cushions. Making cushions is fairly straightforward. It demands that you have some sewing skills and lots of spare time. Follow these instructions to make new cushions for the settee or dinette, berth or cockpit.

Each cushion is made of a fabric cover and a thick piece of high density polyurethane foam wrapped with polyester batting that acts as a "tenderizer" (**Figure 8**). The cover consists of a top and bottom, side strip the width of the cushion and cording. Select closely woven, stain-resistant fabrics, preferably those that are water repellent and rubber backed to reduce stretch. Refrain from using vinyl on the top: easy to clean, it's either freezing in cooler weather or "sweats" in hot weather. Upholstery fabrics come in a wide variety of colors and textures, both solids and prints, but they are expensive; to save money, use less expensive fabrics, such as vinyl or cotton on the bottom. Other fabric options include acrylic (also expensive) or Cordura nylon, commonly used for duffle bags. Use this formula to estimate the amount of fabric to buy based on 1.5m (60") fabric: measure the longest edge of each cushion, add





totals together and multiply by 1.4. Do the same for the foam. Use 7.6cm (3") thick foam for settee cushions and 10.1cm (4") to 15.2cm (6") for berths.

Unless the cushion is perfectly square or rectangular with straight sides, you will need to first make a pattern. Use an existing cushion cover or foam to make the pattern; otherwise use heavy kraft paper or newspaper, joined with tape, slightly larger than the area for the cushion. Position the paper, secure with masking tape and with a pencil press the paper down flat so it creases wherever it hits a bulkhead or the hull. Trim the edge with scissors to within a 12mm (1/2") of the creased line. Retape in place, double check the fit and trim. Before removing, mark patterns, noting orientation (bow, port, top, bottom, etc.) and angles. Use a bevel gauge or carpenter's square and ruler to measure angles: back edges of settee and V-berths are usually angled to fit the contour of the hull. This means the top cover is larger at the back and sometimes, the sides, than the bottom. The

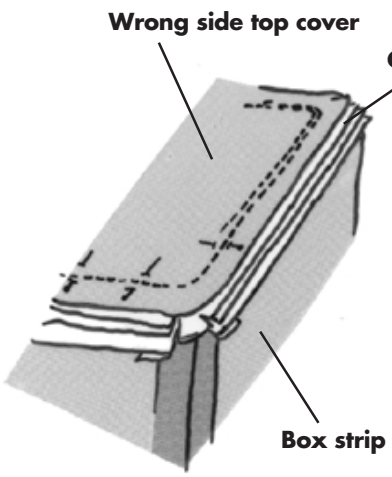


Figure 9: (Left) To make cording, fold strip around cord, wrong sides together, match raw edges and machine base close to cord using a zipper foot. (Right) Cording is sewn to the right side of the cushion top before attaching the box strip. (Center) Overlap ends of cording by 5cm (2").

bevel gauge is the easiest but you can use a carpenter's square and ruler. To do this, lay the square flat on the settee or berth top against the back (creased) edge, measure up the square's vertical edge the thickness of the foam, (10.1cm (4") for example). Place a ruler at the "foam" line, and measure the distance from the outer edge of the square to the hull or bulkhead. Take readings every foot and mark the values on the pattern.

Lay the pattern on the wrong side of the fabric to cut the bottom cover and trace the shape with a chalk pencil. Add 19mm (3/4") seam allowances on all sides. Transfer all orientation marks (bow, etc.) to the fabric. To cut the top cover, lay the pattern on the right side of the fabric and transfer all markings. Remember to cut the top larger when angled. Cut side strips (known in sewing terminology as boxing strips) from one continuous piece of

DIY PROJECTS

fabric, if possible, the thickness of the foam plus 19mm (3/4") seam allowances on all sides. The length of this strip is equal to the distance around the

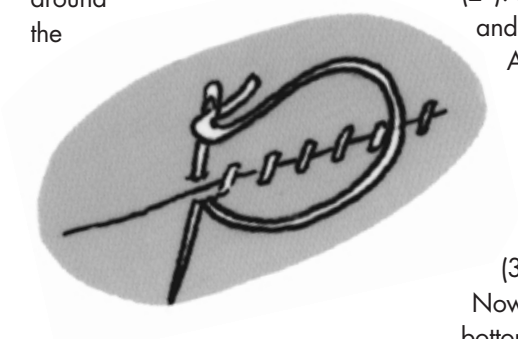


Figure 10: Insert foam, then slipstitch opening closed.

top cover if angled, or paper pattern if straight plus a few extra inches for seams and stretch. Divide into quarters, fold, then mark each fold with chalk pencil.

To make cording, cut bias strips (fabric cut at a 45-degree angle to the selvage) 20.3cm (8") longer than the cushion perimeter and 4.2cm (1-5/8") wide. Fold strip around cord, wrong sides together, matching raw edges. Using a zipper foot, machine baste close to cord (**Figure 9**).

To assemble, sew cording to the right side of the cushion top, matching raw edges; use a zipper foot. To ease corners, clip seam allowances to stitching at corners. Where ends of cording meet, cut off one end of cording so the fabric overlaps the other end by 5cm (2"). Fold under edge and finish stitching.

Attach boxing strip to top cover, right sides together, matching corners, stitching a 19mm (3/4") seam through all layers. Now, sew the boxing strip to the bottom cover and stitch leaving one end open. The size of the opening depends on length: berth cushions need an opening of about 1.2m (4'), usually one end plus part of the back to accommodate large foam pieces.

Use existing foam or paper pattern to cut the foam to size, adding an additional 12mm (1/2") on the ends. This stretches the fabric and gives a smooth, wrinkle-free cover. Again, transfer orientation markings, noting back, front, top, front, angles, etc., before removing pattern. Angle back and side edges to fit. Wrap foam in batting (if using) and insert. Turn under seam allowances and slipstitch opening closed (**Figure 10**).

TED BROWN

Modern fabrics add character and warmth to worn interiors.

It's a good idea to make removable slipcovers to protect fabrics. If washing cushion covers is important, add a zipper to the boxing strip. Purchase a continuous length of plastic zipper the length of the back edge less 20.3cm (8"). Cut a custom piece of boxing strip, the length of the zipper and width of the foam plus seam allowances and an extra 2.5cm (1"). Fold in half lengthwise and cut along the fold line. Turn under 12mm (1/2") on both cut edges and machine baste. Now, attach the zipper. With right sides together, stitch remaining boxing strip to one end of the zipper piece. Leave the other open for final adjustment when sewing to top and bottom covers. Follow above instructions for cushion assembly, omitting references to an open end and slipstitching.

VAPOR BARRIER FOR CEILINGS

Fiberglass boats with uncored hulls and no ceiling are especially susceptible to a bad case of the "sweats." The problem is easily remedied by installing a deckhead liner. This forms a vapor barrier that prevents warm air from contacting cold fiberglass, thereby eliminating condensation.

The simplest type of liner is cork. Sold in rolls 6mm (1/4") thick, it has an adhesive backing that makes installation easy to do. Step one is to make templates of the area to be covered. Use cardboard, kraft paper or outdated charts and a compass or scribe to match angles and fit closely to corners, hatch openings and curved cabin sides — patterns must be exact. When completed, trace the shape onto the cork. Allow edges to meet but do not overlap. Cut with a utility knife. Peel off the paper backing and lay a bead of contact cement along the edges. Apply glue on the deckhead in a few spots to hold the material in place. Fasten to the deckhead and let dry. Cover all seams with transparent tape to reduce the risk of water seeping into the seam and possibly causing rot behind the cork. The tape looks somewhat obtrusive at first but eventually blends in with the cork.

The pilothouse deckhead of Playfair, a 21.6m (72') brigantine based in Toronto, Ont., was covered in cork three years ago and still looks as good as new.

Other insulating materials include fabric and soft vinyl. Available in myriad colors and textures, insulating with fabric is more time-consuming and expensive than cork, but gives a more "homey" appearance. You can also combine the two materials: insulate with cork then cover with an attractive, colorful fabric.

Using an erasable marker or chalk, mark the deckhead into quarters, leaving a centerline down the middle. Make templates of the quarters and trace these out onto thin (less than 6mm-1/4") marine-grade plywood. Allow openings for hatches, deck prisms or access to electrical wiring or instruments. Dry fit the panels and mark screw holes for self-tapping screws. Screws placed along the outer edge are hidden by a trim piece (optional); screws located closer to the centerline are easily covered with decorative caps. Drill holes in the plywood, dry fit again, then drill pilot holes in the deckhead. Using plywood panels for patterns, cut fabric plus a 5cm (2") overlap on the edges.

Remove the panels, apply glue, stretch fabric over the plywood, wrapping around the edges and staple in place on the wrong side. When dry, trim excess fabric with a utility knife. To mark the screw holes on the right side, punch small holes in the fabric with an awl from the underside. Carefully mount the panels in the deckhead. If desired, you can frame the outer edge with a trim piece. Purchase hardwood molding that closely matches the boat's interior. Cut to fit, mitering the corners, then finish with oil or varnish.

R. Bruce MacDonald, Victoria, BC.